ERAGS STEP 3 REPORT

Ecological Risk Assessment of Holly Run and Briar Lake Near the GEMS Landfill, Gloucester Township, New Jersey

Prepared for
***de maximis*, inc.**
186 Center Street
Suite 290
Clinton, NJ 08809

Prepared by

integral consulting inc.
45 Exchange Street
Suite 200
Portland, ME 04101

March 16, 2015

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ADD	Average daily dose
AUF	Area use factor
AVS	Acid volatile sulfide
BEHP	Bis(2-ethylhexyl)phthalate
BERA	Baseline Ecological Risk Assessment
BOD	Biochemical oxygen demand
BW	Body weight
CCMUA	Camden County Municipal Utilities Authority
COPECs	Chemicals of Potential Ecological Concern
CSM	Conceptual Site Model
DOC	Dissolved Organic Carbon
EC_{20}	20% Effect Concentration
ESL	Ecological Screening Level
EDSA	Electronic Data Submittal Application
ERAGS	Ecological Risk Assessment Guidance for Superfund
FSTM	Field Sampling Technical Memorandum
GEMS	Gloucester Environmental Management Services, Inc.
HQ	Hazard Quotient
IDMR	Industrial Discharge Monitoring Report
IR_{sed}	Daily ingestion rate of sediment (kilograms per day)
K_{oc}	Organic carbon partition coefficient
LCV	Lowest chronic values
NOAEL	No observable adverse effect level
NPL	National Priorities List
ORP	Oxidation-reduction potential
pCSM	Preliminary Conceptual Site Model
ROD	Record of Decision
SEM	Simultaneously Extractable Metals

SERAS	Screening Ecological Risk Assessment System
SIB	Sediment Ingestion Benchmark
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific/Management Decision Point
SUF	Seasonal use factor
SVOC	Semivolatile Organic Compound
TAL	Target Analyte List
TEC	Threshold Effect Concentration
TOC	Total Organic Carbon
TRV	Toxicity reference value
VOC	Volatile Organic Compound
WPTM	Work Plan Technical Memorandum

EXECUTIVE SUMMARY

Integral Consulting Inc. (Integral) has prepared this report to present the results of the ecological risk assessment performed for the Gloucester Environmental Management Services, Inc. (GEMS) Landfill site, in Gloucester Township, New Jersey. This report was prepared in response to the 20 June 2013 EPA Region 2 correspondence (Appendix A) to the GEMS Landfill Trustees regarding the results of their Screening Level Ecological Risk Assessment (SLERA) of Briar Lake and Holly Run, which are located proximal to the remediated GEMS landfill, and their request for additional assessment of potential ecological risks.

The overall objective of this assessment is to perform a more refined evaluation of the sediment (and surface water)[1] quality than was performed in the SLERA and to address the questions posed by EPA in their correspondence. The additional assessment was specifically performed under the Ecological Risk Assessment Guidance for Superfund (ERAGS) Step 3 process. The assessment incorporates additional data requested by EPA and obtained in 2014. This additional data builds on the previous data and evaluation presented in 2006. Collectively, this report summarizes the 2014 sampling activities, assesses the prior (2006) and 2014 analytical results, compares these results to refined screening benchmarks, addresses the potential site-specific bioavailability of metals, and evaluates the potential ecological communities in Briar Lake and Holly Run based on site reconnaissance. The collective findings of this work are intended to support the ERAGS Step 3 Scientific/Management Decision Point (SMDP), and determine whether subsequent steps of the ERAGS process should be performed.

Surface sediment and surface water samples were collected in October 2014. These were analyzed for metals, AVS/SEM (sediments only), TOC (sediments only), DOC (surface water), and grain size (sediments only). Samples from several of the proposed locations could no be collected due to the absence of media (e.g., sediments were not available in the rip-rap portions of Holly Run on the GEMS property). Both unfiltered and field filtered surface water samples were collected. In addition, a qualitative ecological community assessment was performed for Holly Run upstream and downstream of Briar Lake using EPA's Rapid Bioassessment Protocol (RBP).

The key findings related to the COPEC metals are the following:

- The October 2014 verification samples had similar metals concentrations to those collected in December 2006 by HydroQual and the split samples tested by EPA. The latter were used as the basis for the EPA SLERA.

[1] Surface water samples for chemical analyses were not collected as part of the 2006 field program so this media was not evaluated in the EPA SLERA.

- Surface Water Results: Low levels of COPEC metals were detected in filtered surface water samples from Briar Lake and Holly Run (surface water was not available from the background locations). These results were all below NJDEP surface water quality criteria (NJDEP 2009), EPA AWQC values (EPA 2009) or other benchmarks (e.g., Suter and Tsao 1996) with exception of dissolved iron in one Holly Run sample. This is not considered to be ecologically significant since the exceedance was isolated to one sample and there is limited habitat available for aquatic receptors at this location.

- Background Sediments: Sediments from the Background locations were below NJDEP sediment benchmarks or regional USGS background concentrations.

- Holly Run Sediments: Sediments were present only in the natural channel portion of Holly Run downstream of Briar Lake. Sediments in Holly Run were below NJDEP sediment benchmarks or background concentrations.

- Briar Lake Sediments: There were exceedances of NJDEP sediment benchmarks for some of the COPEC metals in Briar Lake. These are discussed below:

    - *Arsenic*: Arsenic was greater than the sediment Low Effects Level (LEL) benchmark, site-specific background, and regional background for nearly all of the sediment samples, and three sample locations were approximately twice the sediment Severe Effects Level (SEL), implying a potential for benthic toxicity at these locations. However, it is unclear whether arsenic was site-related. Although arsenic has been detected in the piezometers that are installed along Holly Run, all but one of these have low levels of arsenic (approximately 3 µg/L on average). The single exception is PM-19 (average of 112 µg/L; range from 66.8 to 230 µg/L) which is located near the entry road of the landfill and several thousand feet from Briar Lake. Arsenic was detected in the 2002 treatment plant influent samples (average of 10 µg/L; range from 5.7 to 14.2 µg/L). Pre-remediation groundwater or surface water data for arsenic were not available for review. The 2014 surface water concentrations were also comparable to those reported in most of the piezometer samples (2 to 4 µg/L for total or filtered samples).

    - *Cadmium*: Cadmium was greater than the sediment LEL benchmark at three of the six Briar Lake locations but all were below the SEL benchmark and below the maximum site background. The cadmium LEL exceedances are not considered ecological significant because the AVS/SEM/TOC analysis showed that all of the divalent metals (including cadmium) are not bioavailable and unlikely to cause any toxicity

  - *Iron*: There are no sediment benchmarks available for iron, so the observed concentrations were compared to the site background samples and regional background. All of the Briar Lake samples were greater than the maximum site background samples and three were also greater than the regional background data. Iron flocculent is present throughout Briar Lake which likely skewed the iron results. Although above background concentrations there does not appear to be any ecological effects related to the iron flocculent.

  - *Selenium*: Selenium was detected in three of the six samples from Briar Lake. There are no sediment benchmarks available for selenium, so the observed concentrations were compared to the site background samples and regional background. All of the detected Briar Lake samples were greater than the maximum site background samples and two were slightly greater than the regional background data.

  - *Zinc*: Zinc was greater than the sediment LEL benchmark but all locations were below the SEL benchmark and one of the samples was greater than the site background samples. The zinc LEL exceedances are not considered ecological significant because the AVS/SEM/TOC analysis showed that all of the divalent metals (including zinc) are not bioavailable and unlikely to cause any toxicity.

- None of the COPEC metal concentrations in the Briar Lake sediments represented a potential hazard from ingestion for herons (except for iron) or ducks. Despite the exceedances of NJDEP sediment criteria, Briar Lake is being utilized by aquatic organisms (amphibians) and semi-aquatic organisms (herons and ducks).

- The rip-rap portions of Holly Run on the GEMS property does not provide suitable habitat for ecological receptors, such as benthic invertebrates, chiefly due to the absence of contiguous sediments. The natural channel of Holly Run downstream of Briar Lake has sufficient sediment and stable hydrology to maintain aquatic receptors. The Rapid Bioassessment (RBA) score was much higher for the natural channel portions for Holly Run relative to the on-property portions.

- Briar Lake appears to be filling with sediments since the Phase I remedial action was implemented. There is a layer of iron flocculent that overlies the sediment bed in the lake, but this is not present downstream of the lake. These results suggest that the elevations of the inlet and exit culverts are properly positioned to minimize release of sediments from the lake.

SMDP Recommendations

Based upon the assessment performed as part of ERAGS Step 3, the following Scientific/Management Decision Points are recommended:

- There are no apparent ecological impacts related to sediment or surface COPEC metal concentrations in the background areas or within Holly Run. Therefore, no further evaluation of these areas is warranted.

- There were exceedances of sediment benchmarks for arsenic, iron and zinc in Briar Lake. Of these, only arsenic may be of potential concern for toxicity at some of the locations. However, it is unclear whether the arsenic in Briar Lake sediments is site-related (based upon review of the available groundwater and Holly Run underdrain data) or from other sources. Furthermore, given that the Briar Lake has extensive algal growth, and is being utilized by aquatic organisms (amphibians) and semi-aquatic organisms (herons and ducks), it is unlikely that COPEC metals results pose significant ecological risk.

- Briar Lake is properly operating as a retention pond for the GEMS property and adjoining areas. Sediments have been accumulating particularly on the east side near the Holly Run inlet, and have significantly reduced the depth of the lake in this area (water column depth of a few inches), relative to the original Phase I remediation plans (water column depth of 2-ft). It is not clear whether this sediment accumulation is derived exclusively from runoff from the GEMS property, given that there is no extensive sediment accumulation within the rip-rap channel of Holly Run adjoining the capped landfill, and the GEMS property is landscaped (i.e., low potential for suspended solids runoff, except perhaps from dirt roadways). The sediments within the lake are also covered with a layer of iron flocculent. Although there are no ecological impacts apparent from the iron flocculent in Briar Lake, this material affects the aesthetic value of the lake.

Based on the ERAGS Step 3 assessment, further ecological evaluation of Holly Run or Briar Lake is not required and the ERAGS process can be exited at this stage.

1 INTRODUCTION

Integral Consulting Inc. (Integral) has prepared this report to present the results of the ecological risk assessment performed for the Gloucester Environmental Management Services, Inc. (GEMS) Landfill site, in Gloucester Township, New Jersey. This report was prepared in response to the 20 June 2013 EPA Region 2 correspondence (Appendix A) to the GEMS Landfill Trustees regarding the results of their Screening Level Ecological Risk Assessment (SLERA) of Briar Lake and Holly Run, which are located proximal to the remediated GEMS landfill, and their request for additional assessment of potential ecological risks.

The overall objective of this assessment is to perform a more refined evaluation of the sediment (and surface water)[2] quality than was performed in the SLERA and to address the questions posed by EPA in their correspondence. The additional assessment was specifically performed under the Ecological Risk Assessment Guidance for Superfund (ERAGS) Step 3 process. The assessment incorporates additional data requested by EPA and obtained in 2014. This additional data builds on the previous data and evaluation presented in 2006. Collectively, this report summarizes the 2014 sampling activities, assesses the prior (2006) and 2014 analytical results, compares these results to refined screening benchmarks, addresses the potential site-specific bioavailability of metals, and evaluates the potential ecological communities in Briar Lake and Holly Run based on site reconnaissance. The collective findings of this work are intended to support the ERAGS Step 3 Scientific/Management Decision Point (SMDP), and determine whether subsequent steps of the ERAGS process should be performed.

1.1 SITE BACKGROUND

The GEMS Landfill (EPA ID#: NJD980529192) is located in a predominantly rural and residential area of Gloucester Township, Camden County, New Jersey (Figure 1-1). GEMS Landfill was added to the National Priorities List (NPL) in September 1983, having received solid, liquid and hazardous wastes and hazardous substances from the 1950s through late 1980s. Following completion of the RI/FS, a ROD was prepared in 1985 that presented the remediation plan, which included re-contouring the landfill, construction of a landfill cap, installation of surface water controls, installation of a landfill gas collection and treatment system, remediation of Holly Run and Briar Lake sediments, and installation of a security fence. This Phase I remedial measures were completed in 1993.

The Phase II remedial measure involved the construction of a groundwater and leachate extraction and treatment system, which underwent pilot testing from April 2002 until January 2003, with full operation beginning in 2005. The intercepted groundwater is pumped to an on-

[2] Surface water samples for chemical analyses were not collected as part of the 2006 field program so this media was not evaluated in the EPA SLERA.

site pretreatment facility prior to discharge to the Gloucester Township Municipal Utilities Authority (GTMUA) sewage system for subsequent final treatment at the Camden County Municipal Utilities Authority (CCMUA) plant. On-site treatment includes Equalization, Solids Separation, and Carbon Filtration. Residual solids that are removed by the process are transported off site by truck to a landfill permitted to accept the type of solid waste that is produced. The pretreated groundwater is routinely sampled and analyzed to ensure that it meets discharge limits established by the CCMUA. In the interim period between the landfill closure and continuous operation of the groundwater extraction and treatment system, untreated groundwater from the Holly Run underdrain and groundwater extraction wells were discharged to the adjoining stream (Holly Run).[3]

The period between the completion of the Phase I action and start-up of the Phase II treatment system operation prompted EPA to request the GEMS Trust to assess sediment quality of the downstream portions of Holly Run and Briar Lake. A Work Plan was developed in 2006 for this effort (HydroQual 2006), samples were collected in December of that year, and the results were presented in HydroQual (2007). A summary of the results from the 2006 investigation was provided as an appendix to the Work Plan Technical Memorandum (WPTM; Integral 2014a). This appendix is repeated herein (as Appendix B) because these historical results will also be evaluated as part of the ERAGS Step 3 assessment.

1.2 SITE ENVIRONMENTAL SETTING

The key site features that are the focus of this evaluation are shown in Figure 1-1. Holly Run is an intermittent stream that originates near the southeast corner of the GEMS landfill and flows adjacent to the northeast side of the property. The historical channel for Holly Run was modified as part of the landfill closure; the portion of the stream adjacent to the landfill and on most of the GEMS property is a rip-rap channel. There is a small natural channel for Holly Run located in what appears to be a small wetland area southeast of the landfill near Erial Road as well as near Briar Lake.

Holly Run leaves the landfill property and flows into Briar Lake, which is located northwest of the landfill near the intersection of Primrose Lane and Briar Lane. This is a small, roughly oval lake, and 0.9 acre in size[4]. Sediments from Briar Lake were removed, the lake edges were re-graded, and new culverts were installed, during the GEMS Landfill Phase I action. Briar Lake is currently fenced and bounded by residences on all but its more northern side; the latter is bounded by a wooded area. There are culvert pipes on the west side of the lake, which discharge to a natural channel for Holly Run. This portion of Holly Run traverses an

[3] Treated groundwater was discharged to Holly Run during the pilot testing from April 2002 through January 2003.
[4] This was updated from the 0.8 acre quoted in prior documents and reflects the open water area from the image used for figures presented in this report.

undeveloped area and continues on to Holly Lake, approximately 1,500 feet northwest of Briar Lake. Holly Lake discharges to the South Branch of Timber Creek.

1.3 EPA SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

A subset of the sediments collected in December 2006 were analyzed separately by EPA and used to prepare their Screening Level Ecological Risk Assessment (SLERA) in 2009. The EPA SLERA addresses the first two steps of the eight-step ERAGS (USEPA 1997a; Figure 1-2). As discussed in Section 6 of the SLERA, there are three possible SMDP outcomes for a SLERA:

1. There is adequate information to conclude that ecological risks are negligible and therefore there is no need for remediation on the basis of ecological risk;

2. The information is not adequate to make a decision at this point, and the ERA process should continue to Step 3; or

3. The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted (continue to Step 3 of the ERA process).

EPA used the Screening Ecological Risk Assessment System (SERAS) program developed by Signal Corporation (Signal Corporation 2004) to assess potential risks to aquatic organisms for non-radiological chemicals. This is a database-driven program that compares the observed chemical results on an individual sample basis to screening benchmarks. The currently available version (v 2.03) allows comparison to a suite of potential sediment benchmarks.

For the SLERA, EPA compared the individual sample results to the conservative screening benchmarks, with the results presented as hazard quotients (ratios of observed results to the benchmark). The SLERA concluded that there was the potential for adverse ecological effects from exposure to metals and a small number of organics in Holly Run and Briar Lake. The chemicals of potential concern (COPECs) identified by EPA are listed in Table 1-1.

The WPTM (Integral 2014a) re-assessed the COPEC list from the SLERA and concluded that there was no need to further evaluate the organics shown in Table 1-1. Subsequent to accepting the WPTM EPA requested additional evaluations of two of the organics (naphthalene and chlorobenzene). These evaluations are presented in the Uncertainty Section of this report.

The overall conclusion of the EPA SLERA was that an ERAGS Step 3 assessment should be performed, but in their letter of June 20, 2013, EPA requested that the GEMS Trust perform a Baseline Ecological Risk Assessment (BERA) to assess the potential ecological risks in Holly Run and Briar Lake. The EPA letter specifically mentions concentrations of cadmium, arsenic, iron, selenium and zinc in sediment exceeded ecological benchmarks and background values, as a basis for performing the BERA. Furthermore, EPA requested that the BERA should:

1. Provide EPA with current/additional monitoring data;
2. Help EPA learn more about the potential ecological risk at Briar Lake and Holly Run;
3. Help EPA better understand the meaning of sampling data collected; and
4. Provide information to assist EPA in determining whether or not there is still a potential ecological risk at Briar Lake and Holly Run.

Because the previous SLERA was a screening-level and conservative evaluation, by nature it did not consider many of the factors that more refined evaluations may consider to characterize risk. For example, factors associated with the potential for an exposure and risk to ecological receptors, such as bioavailability reductions, presence of suitable habitat, site-specific total organic carbon content, and related factors[5].

1.4 ERAGS STEP 3 OBJECTIVES

The objectives of the ERAGS Step 3 evaluation include the following:

- Summarize the results of the 2014 field sampling program to update the current sediment data, better characterize surface water quality, examine factors that influence metal bioavailability, and present the results of the qualitative ecological community assessment.
- Assess the 2014 chemical results using refined screening benchmarks, use of site specific total organic carbon data, and spatial analysis. This will also include an evaluation of the potential bioavailability of the sediment metals.
- Address the four questions identified by EPA based on the results of their SLERA.
- Compile and summarize the information needed to address the elements of the ERAGS Step 3 SMDP following the collection and evaluation of additional field data.
- Determine whether a comprehensive BERA is required based upon the results of the additional sampling, data assessment, refined screening, and SMDP evaluation.

Section 2 presents the results from the 2014 field investigation. Section 3 of this ERAGS Step 3 Report summarizes the Problem Formulation, presents the updated Conceptual Site Model (CSM) and the assessment of potential fate and transport pathways. Section 4 presents the results of the 2014 filed investigation, compares the 2014 to the prior (2006) results, and

[5] These are considered in later steps of the ERAGS process.

compares the COPEC results to the revised benchmarks. Section 5 summarizes the SMDP evaluation and recommendation. Additional supporting information is provided in appendices.

2 OCTOBER 2014 FIELD INVESTIGATION

The WPTM (Integral 2014a) presented the proposed field program to support the ERAGS Step 3 Assessment. The following field activities were performed:

- Collect additional field samples of sediments and surface water to supplement and update the existing dataset.
- Perform a qualitative ecological assessment of Holly Run, Briar Lake and the background locations to determine what types of ecological receptors may be present or can utilize Holly Run and Briar Lake.

The field sampling methodologies that were used to collect these samples are presented in the FSTM (Appendix C). A brief synopsis of the methods is presented by media in the sections that follow below. The sediment and surface water sampling locations are shown on Figure 2-1. The sample coordinates are shown in Table 2-1.

In addition to the field investigation activities, historical groundwater and/or leachate sample data were reviewed to determine what types of chemicals may have been released to Holly Run during the period between landfill closure and groundwater treatment start up. These results are summarized in this section of the report.

2.1 SAMPLE NOMENCLATURE

A similar sampling nomenclature to that used for the 2006 sampling event was used for the 2014 samples. To ensure clarity, the 2014 analytical samples include a media acronym (SW for surface water and SED for sediment) and the sample year in the Sample ID. For example, the recollected sediment sample from location BL-01 was identified as SED-BL14-01. This facilitates comparisons of results from the same sampling locations between the two sampling events.

2.2 CHANGED FIELD CONDITIONS

The WPTM (Integral 2014a) presented the proposed sampling locations for the ERAGS Step 3 field program. There were modifications to the original proposed field investigation based on field conditions and other adjustments that were made in the field. These are in the sections that follow and discussed more fully in the FSTM (Appendix C).

2.3 ANALYTICAL LABORATORY AND DATA VALIDATION

TestAmerica Laboratories of Burlington, Vermont, was used as the analytical laboratory for the 2014 surface water and sediment chemical analyses. TestAmerica provided electronic data deliverables (EDD) in a format consistent with NJDEP's Electronic Data Interchange Manual (NJDEP 2013).

Data validation of the analytical samples was performed by Integral chemistry staff. This included a review of all laboratory summary forms of quality control and instrument performance data, instrument raw data, and recalculation of instrument and sample results. The data validation was based on criteria described in the Quality Assurance Project Plan (QAPP; Integral 2014b). The data validation report and data usability assessment is provided as Appendix E to the ERAGS Step 3 Report. Although a portion of the analytical data were qualified as estimated (J or UJ qualifiers), none were rejected, and all of the results are acceptable for their intended use.

Integral prepared a Microsoft Access database of the 2006 sample results (from HydroQual and EPA) as well as the validated 2014 results. The TestAmerica EDDs, completed chain of custody forms, and a copy of the Microsoft Access database are included on the CD (Appendix I) provided with the ERAGS Step 3 Report.

2.4 SURFACE SEDIMENT COLLECTIONS

Surface sediment samples were collected using one of three methods, which are briefly summarized below:

- In the narrow stream channel of Holly Run and the background locations where overlying water was present, an AMS Multi-Stage Sludge and Sediment sampler was used to obtain 2 inch diameter cores. Up to three cores were collected (or attempted at locations in the Holly Run rip-rap channel) and composited at each location to obtain sufficient mass for chemical analysis. Sediment cores from 0 to 6 inches in total depth were extruded from the coring device.

- In Briar Lake, where a boat was used to collect the samples, an Ekman dredge sampler was employed to acquire a 0 to 6 inch sediment grab for samples underlying 1 to 2 feet of water.

- At locations with no overlying water (e.g., background location BG-05), the deposited sediment sample was collected using a soil sampling technique of clearing the sampling location, excavating a sample hole to the 6 inch depth and slicing 0 to 6 inch sections into a stainless steel bowl.

Samples for AVS/SEM were collected first from the sampling equipment to minimize exposure to overlying air. For the remaining analytes the samples were homogenized prior to placement in sample containers. Additional details regarding the sample collections are provided in the Field Technical Sampling Memorandum (FSTM; Appendix C).

2.4.1 Sediment Sampling Modifications

As was observed during the December 2006 sampling event (HydroQual 2007), sediment samples could not be collected from all of the planned locations due to minimal accumulation of sediment or the presence of an unacceptable matrix (e.g., cobble). These are summarized below.

- *SED-BG14-01 (relocated to SED-HR14-06)*: There was no surface water present at the original proposed sample location for the upstream background, BG-01. This location was moved further downstream where water was present. The new location is adjacent to the landfill and was renamed HR-06. Sediment depth at this location was 0 to 2 inches before rip-rap was encountered. Core attempts were made at the original and adjusted locations with similar results. Appendix C shows photographs taken of the sediment depth and example core attempted at this location.

- *SED-HR14-01*: Sediment depth was less than 1 inch before rip-rap was encountered at this location. This was a recollection attempt at HR-01 where a sediment sample could not be acquired during sampling in 2006 by HydroQual (2007). Appendix C shows a photograph of rip-rap encountered in the coring device at HR-01.

- *SED-HR14-02*: Sediment depth was 0 to 3 inches and substrate consisted of rocks and pebbles. This was a recollection attempt at HR-02 where a sediment sample could not be acquired during sampling in 2006 by HydroQual (2007). Appendix C shows photographs of HR-02 and the type of sediment core matrix acquired at this location. The sample matrix was predominately made up of gravel and pebbles with a small proportion of coarse sand. A total of three cores were attempted all with maximum depths of 3 inches and containing mostly gravel and pebbles.

- *SED-HR14-03*: Geotextile liner which underlies the rip-rap channel was partially exposed at this location. There was no sediment deposition (other than iron floc) on top of exposed liner. This was a recollection attempt at HR-03 where a sediment sample could not be acquired during sampling in 2006 by HydroQual (2007). Appendix C shows a photograph of the liner with iron flocculent on the liner and a photograph of the sample location with rip-rap on top of the liner. Integral chose not to acquire a subsurface sample at this location below the geotextile liner.

No additional sediment sampling locations were collected as part of the field sampling event. The field duplicate, matrix spike, and matrix spike duplicate for sediments were collected from a Briar Lake location (BL-01).

2.5 SURFACE SEDIMENT RESULTS

The COPEC and non-COPEC metal results for the surface sediment are discussed below by sampled area. The comparisons of the COPEC results to the refined sediment benchmarks are presented in Section 4. The field quality control samples consisted of a field duplicate and a field rinsate blank sample. The field duplicate sample was evaluated separately from the parent sample and treated as an independent sample for the data summaries. The field rinsate blank results are presented in Appendix D.

The COPEC Metal, Non-COPEC Metal, and general parameter (sediment pH, percent solids and total organic carbon) results are summarized in Table 2-2. The AVS/SEM results are summarized in Table 2-3. The grain size results are summarized in Table 2-4. Sampling locations are shown on Figure 2-1. Individual sample results are presented in Appendix D.

For the summary table, the average concentrations were calculated by setting non-detect results to one-half the reported detection limits. In some cases the calculated average was greater than the maximum detected concentration, in which case the latter was reported as the average concentration in theses tables. The "U" qualifier was included in the data summaries discussed below when the reported detection limits are presented for the non-detect sample results.

2.5.1 Background Locations Inorganic Results

Surface sediment samples for inorganic analysis were collected from three background locations (SED-BG14-03, SED-BG14-04, and SED-BG14-05). These samples were located south, west, and east (respectively) of the GEMS landfill (Figure 2-1).

The results for the five inorganic COPECs from the background locations are summarized below. The comparisons to the sediment benchmarks are presented in the Section 4.

- *Arsenic*: Arsenic was detected in one of the three background samples. The single detection was 3.2 mg/kg$_{dw}$ in sample SED-BG14-05, which was collected within the Holly Run drainage upgradient of the GEMS property. The detection limits in the two remaining samples were 1.7 U and 3.65 U mg/kg$_{dw}$. The average concentration across the three background samples was 2.0 mg/kg$_{dw}$.

- *Cadmium*: Cadmium was detected in all three background samples with an average concentration of 1.1 mg/kg$_{dw}$ (range: 0.34 to 2 mg/kg$_{dw}$). The maximum detected result

was reported in sample SED-BG14-04, and the minimum detected result was from SED-BG14-05.

- *Iron*: Iron was detected in all three background samples with an average concentration of 5,640 mg/kg$_{dw}$ (range: 1,070 to 14,000 mg/kg$_{dw}$). The maximum detected result was reported in sample SED-BG14-05, and the minimum detected result was from SED-BG14-04. There was no evidence of iron staining in either of these samples.

- *Selenium*: Selenium was detected in one of the three background samples. The single detection was 1.5 mg/kg$_{dw}$ in sample SED-BG14-03, which was collected south of the GEMS property. The detection limits in the two remaining samples were 3.2 U and 5.5 U mg/kg$_{dw}$.

- *Zinc*: Zinc was detected in one of the three background samples. The single detection was 447 mg/kg$_{dw}$ in sample SED-BG14-05, which was collected within the Holly Run drainage upgradient of the GEMS property. The calculated average was 151 mg/kg$_{dw}$ using half the reported non-detect values for the remaining two samples (3.9 U and 10.6 U mg/kg$_{dw}$).

Five of the non-COPEC metals (beryllium, potassium, silver, sodium and thallium) were not detected in any of the surface sediments from the background locations. Results for the remaining non-COPEC metal results are discussed in Appendix D.

2.5.2 Briar Lake Inorganic Results

A total of six surface sediment samples for inorganic analysis were collected from Briar Lake (five locations plus one field duplicate). The field duplicate is evaluated as an independent sample for these summaries. Sampling locations are shown on Figure 2-1.

The results for the five inorganic COPECs from Briar Lake are summarized below. The comparisons to the NJDEP Ecological Screening Criteria (NJDEP 2009) and alternate sediment benchmarks are presented in Section 4.

- *Arsenic*: Arsenic was detected in all six Briar Lake samples with an average concentration of 42 mg/kg$_{dw}$ (range: 9 to 72.8 mg/kg$_{dw}$). The maximum concentration was observed in SED-BL14-02, which was collected near the center of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was greater than that observed in the site-specific background samples (2.0 mg/kg$_{dw}$).

- *Cadmium*: Cadmium was detected in all six Briar Lake samples with an average concentration of 0.9 mg/kg$_{dw}$ (range: 0.37 to 1.4 mg/kg$_{dw}$). The maximum concentration was observed in SED-BL14-03, which was collected near the exit culvert of the lake. The

minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was less than that observed in the site-specific background samples (1.1 mg/kg$_{dw}$).

- *Iron*: Iron was detected in all six Briar Lake samples with an average concentration of 121,250 mg/kg$_{dw}$ (range: 25,500 to 217,000 mg/kg$_{dw}$). Nearly all of the samples exhibited iron floc or staining, so the elevated iron concentrations were not unexpected. The maximum concentration was observed in SED-BL14-02, which was collected near the center of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was greater than that observed in the site-specific background samples (5,640 mg/kg$_{dw}$).

- *Selenium*: Selenium was detected in three of the six Briar Lake samples with an average concentration of 3.6 mg/kg$_{dw}$ (range of detects: 3.7 to 4.7 mg/kg$_{dw}$). The non-detect values ranged from 5 U to 6.6 U mg/kg$_{dw}$ in the remaining samples. The maximum observed concentration was in sample SED-BL14-03, which was collected near the exit culvert of the lake. The minimum observed concentration was in sample SED-BL14-02, which was collected near the center of the lake. The average concentration was greater than the average (and single detection) in the site-specific background samples (1.5 mg/kg$_{dw}$).

- *Zinc*: Zinc was detected in all six Briar Lake samples with an average concentration of 413 mg/kg$_{dw}$ (range: 146 to 663 mg/kg$_{dw}$). The maximum concentration was observed in SED-BL14-03, which was collected near the exit culvert of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was greater than that observed in the site-specific background samples (153 mg/kg$_{dw}$).

Four of the non-COPEC metals (potassium, silver, sodium, and thallium) were not detected in any of the surface sediments from Briar Lake. Results for the remaining non-COPEC metal results are presented in Appendix D.

2.5.3 Holly Run Inorganic Results

Surface sediment samples for inorganic analysis were collected from two Holly Run locations (SED-HR14-04 and SED-HR14-05). Both of these samples were located downstream of Briar Lake (Figure 2-1). There was insufficient surface sediment available at the other proposed Holly Run sampling locations.

The results for the five inorganic COPECs from Holly Run are summarized below. The comparisons to the NJDEP Ecological Screening Criteria (NJDEP 2009) and alternate sediment benchmarks are presented in Section 4.

- *Arsenic*: Arsenic was detected in both Holly Run samples with an average concentration of 1.65 mg/kg$_{dw}$ (range: 1.6 to 1.7 mg/kg$_{dw}$). The maximum concentration was observed in SED-HR14-04, which was collected within Holly Run just downstream of the discharge from Briar Lake, although both samples had similar concentrations. The average arsenic concentration was less than that observed in the site-specific background samples (2.0 mg/kg$_{dw}$).

- *Cadmium*: Cadmium was detected in one of the two Holly Run samples (SED-HR14-05; 0.97 mg/kg$_{dw}$). The detection limit in sample SED-HR14-04 was 0.11 mg/kg$_{dw}$. The single detection was below the average concentration (1.1 mg/kg$_{dw}$) from the site-specific background samples.

- *Iron*: Iron was detected in both Holly Run samples with an average concentration of 3,545 mg/kg$_{dw}$ (range: 2,620 to 4,470 mg/kg$_{dw}$). The maximum concentration was observed in SED-HR14-04, which was collected within Holly Run just downstream of the discharge from Briar Lake. There was no evidence of iron staining in either of these samples. The average concentration was less than that observed in the site-specific background samples (5,640 mg/kg$_{dw}$).

- *Selenium*: Selenium was detected in one of the two Holly Run samples (SED-HR14-05; 1 mg/kgdw). The detection limit in sample SED-HR14-04 was 3.7 mg/kg$_{dw}$. The single detection was below the single detection (1.5 mg/kg$_{dw}$) in the site-specific background samples.

- *Zinc*: Zinc was detected in one of the two Holly Run samples (SED-HR14-04; 10.4 mg/kg$_{dw}$). The detection limit in sample SED-HR14-05 was 6.6 mg/kg$_{dw}$. The single detection was below the average concentration (151 mg/kg$_{dw}$) in the site-specific background samples.

Six of the non-COPEC metals (antimony, calcium, nickel, silver, sodium or thallium) were not detected in any of the surface sediments from Holly Run. Results for the remaining non-COPEC metal results are presented in Appendix D.

2.5.4 AVS/SEM Results

This section provides a summary of the AVS/SEM results. The bioavailability assessment using the AVS/SEM results is presented in Section 4.2. AVS/SEM samples were collected only from those locations where standing water was present[6]. AVS/SEM was analyzed following the methods outlined in USEPA (1991). The results are summarized in Table 2-2 and the sample-specific results are presented in Appendix Table D-3. The sum of the SEM metals was

[6] Water cover is needed to provide anoxic conditions for the sediments and ensure valid AVS results (e.g., USEPA 2001).

calculated as the sum of the detected metal results. The area-specific AVS/SEM results are presented below.

Background Locations

AVS/SEM results were available from two of the background locations (SED-BG14-03 and SED-BG14-04) that had standing water present. AVS was detected in one of the two background locations (SED-BG14-04; 0.93 μmoles/g). The detection frequency of the six SEM metals varied between these two samples. Sample SED-BG14-03 had a positive result for SEM-mercury only (0.00013 μmoles/g), while sample SED-BG14-04 had three metals (SEM-cadmium, lead and mercury) detected. Neither sample had any detectable SEM-copper, nickel or zinc. The sum of the SEM metals was larger in sample SED-BG14-04 than SED-BG14-03 (0.025 and 0.00013 μmoles/g, respectively).

Briar Lake

AVS/SEM results were available from five Briar Lake samples (plus one field duplicate). AVS was detected in all of the Briar Lake samples with the highest concentration reported in sample SED-BL14-03 (166 μmoles/g). All six of the SEM metals were detected in these samples, except for SEM-cadmium in BL14-05. Sample SED-BL14-03 consistently had the highest individual SEM metal concentrations reported across the Briar Lake samples. The sum of the SEM metals ranged from 1.62 to 12.52 μmoles/g. The highest sum of SEM metals was in SED-BL14-03.

Holly Run

AVS/SEM results were available from two of the Holly Run samples (SED-HR14-04 and SED-HR14-05), both of which were located downstream of Briar Lake. AVS was detected in one of the Holly Run samples (HR14-05; 7.4 μmoles/g). The detection frequency of the six SEM metals varied between these two samples. Sample HR14-04 had a four metals detected (SEM-copper, lead, mercury and zinc) while sample HR14-05 had five metals detected (SEM-cadmium, lead, mercury, nickel and zinc). The sum of the SEM metals were similar between sample HR14-04 (0.13 μmoles/g) and sample HR14-95 (0.15 μmoles/g).

2.5.5 Total Organic Carbon

The TOC contents of all of the sediments collected in 2014 were determined using the Lloyd-Khan Method, which is a pyrolysis method where the organic carbon is converted to carbon dioxide and measured by a differential thermal conductivity detector. The results are summarized in Table 2-2 and the sample-specific results are presented in Appendix Table D-1a. The area-specific TOC results are presented below.

Background Locations

Sediment TOC results were available from all three of the background location samples. The average TOC of these samples was 58,410 mg/kg$_{dw}$ (5.8%), with a range of 7,830 to 143,000 mg/kg$_{dw}$ (0.78 to 14.3%). The lowest sediment TOC was from SED-BG14-05, which was located upstream of the GEMS property within Holly Run. The maximum sediment TOC concentration was from SED-BG14-03, which was located south of the GEMS property within a red maple swamp.

Briar Lake

Sediment TOC results were available from all six of the Briar Lake samples (five locations plus one field duplicate). The average TOC of these samples was 58,017 mg/kg$_{dw}$ (5.8%), with a range of 18,700 to 101,000 mg/kg$_{dw}$ (1.87 to 10.1%). The lowest sediment TOC was from SED-BL14-01, which was located near the discharge of the entry culvert from Holly Run into the lake. The maximum sediment TOC concentration was from SED-BL14-02, which was collected near the center of the lake.

Holly Run

Sediment TOC results were available only from the two Holly Run locations downstream of Briar Lake (HR14-04 and HR14-05). The average TOC of these samples was 15,135 mg/kg$_{dw}$ (1.5%), with a range of 5,670 to 24,600 mg/kg$_{dw}$ (0.57 to 2.26%). The maximum sediment TOC concentration was from the furthest downstream sample, which was located within the natural channel of Holly Run.

Across all of the samples, the average TOC concentrations of the background and Briar Lake samples were nearly identical (5.84 and 5.80%, respectively) and these were greater than the average of the two downstream Holly Run sediment samples (1.51%).

2.5.6 Laboratory pH

The laboratory pH of all of the sediments collected in 2014 was determined using an electrometric method following TAL-Burlington SOP BR-WC-021, which was based on EPA Method 9045. Sediment (or soil) pH measurements have a very short hold time (few hours) so all of the pH results were qualified as estimates during data validation since this was determined at the analytical laboratory. The results are summarized in Table 2-2 and the sample-specific results are presented in Appendix D. The area-specific pH results are presented below.

Background Locations

Sediments were available from all three of the background location samples. The average laboratory pH of these samples was 5.66, with a range of 4.68 to 6.3. The lowest sediment laboratory pH was from SED-BG14-04, which was located west of the GEMS property. The maximum sediment laboratory pH was from SED-BG14-05, which was located upstream of the GEMS property within Holly Run.

Briar Lake

Sediments were available from all six of the Briar Lake samples (five locations plus one field duplicate). The laboratory pH values of these samples were slightly below neutral. The average laboratory pH of these samples was 6.76, with a range of 6.63 to 6.99. The lowest sediment laboratory pH was from SED-BL14-01, which was collected near the entry culvert from Holly Run. The maximum sediment laboratory pH was from SED-BL14-04, which was collected on the north side of the lake.

Holly Run

Sediments were available only from the two Holly Run locations downstream of Briar Lake (HR14-04 and HR14-05). The average laboratory pH of these samples was 5.72, with a range of 5.43 to 6.01. The lowest sediment laboratory pH was from SED-HR14-04, which was collected near the discharge of Briar Lake. The maximum sediment laboratory pH was from SED-HR14-05, which was collected further downstream in Holly Run.

Across these three areas, the average pH of the background and Holly Run samples were nearly identical (5.66 and 5.72, respectively) and both were lower (i.e., more acidic) than the average in Briar Lake (6.76).

2.5.7 Grain Size Analysis

All of the sediments collected in 2014 were evaluated for grain size by sieve and hydrometer following ASTM Method D422. The results are summarized in Table 2-4 and discussed in detail in Appendix D. The key results are summarized below.

Background Locations

Grain size analyses were performed on three surface sediment samples from background locations. Based on the average sand and silt content of these samples (20% silt and 77% sand; Table 2-4) these sediments would be considered silty sands. The silt content was highest at BG14-03, which is located south of the landfill. BG14-05, which was located within the Holly Run drainage upstream of the GEMS property, had the lowest silt content (7.8%) and highest clay content (4%) relative to the other background samples.

Briar Lake

Grain size analyses were performed on five surface sediment samples (plus one field duplicate) from Briar Lake. On average, the Briar Lake sediments contained more silt than observed at the background locations. Based on the average sand and silt content of these samples (47% silt and 40% sand; Table 2-4) these sediments would be considered sandy silts. However, review of Appendix Table D-3 shows that the grain size varied across the lake surface sediments. The sand content was highest at the main culvert from Holly Run (BL14-01; 77.2% sand) and a small surface runoff point from Primrose Lane into the lake (BL14-05; 80% sand). Both of these samples had low clay contents (4.3 and 4.8%, respectively) and moderate amounts of silt (18.5 and 15.2%, respectively). The three remaining Briar Lake samples were predominantly silts (silt contents ranged from 58.6 to 81.9%; Appendix Table D-3), with variable sand and clay contents. Spatially, the sediment substrate shifts from a silty sand near the Holly Run discharge culvert (BL14-01), to a sandy clayey silt in the center of the lake (BL14-02), and then to a clayey sandy silt near the exit culvert (BL14-03). The water depth of the lake also increases along this same transect, with only a few inches of water near BL14-01 and deeper water (approximately 16" at the time of sampling; Appendix C) near BL14-03.

Holly Run

The two Holly Run samples were collected downstream of Briar Lake. Sample HR14-04 was collected just downstream of the lake when the natural channel was apparent, and HR14-05 was collected further downstream. Both sediments were predominantly sand (average of 85%; Table X4) which consisted predominantly of fine sands (Appendix Table D-3). Sample HR14-05 contained more silt (15.2%) relative to HR14-04 (4.8%), which was not unexpected since sample HR14-05 was collected from an undeveloped wooded area downstream of Briar Lake and likely receives more allochthonous material than HR14-04 which was located closer to Briar Lake.

2.6 SURFACE WATER COLLECTIONS

The collection of surface water for chemical analyses was not included as part of the 2006 sampling effort. This was raised as a source of uncertainty in the EPA SLERA, which stated that *"…aquatic organisms are exposed to COPCs in their environment via contact with both sediment and surface water, the lack of surface water data results in an underestimate of risk to aquatic organisms at this Site."* To address this uncertainty, surface water samples were collected as part of the October 2014 field investigation.

Surface water samples were collected using a Geotech Geopump™ Series II peristaltic pump. A combination of dedicated C-Flex™ and fluorinated ethylene propylene (FEP) lined polyethylene tubing was used for sampling. Surface water samples were pumped directly from the site at a depth of approximately 1 to 3 inches below the surface where possible. Total TAL Metals were acquired first without filtration and preserved with nitric acid. Dissolved TAL Metals and

organic carbon samples were acquired second after fitting a Geotech 0.45 μm high-capacity Dispos-a-Filter™ to the tubing. Dissolved TAL metals were preserved with nitric acid and dissolved organic carbon (DOC) samples were preserved in amber glass jars with sulfuric acid. Surface water sample collections sheets are provided in the FSTM (Appendix C) for each location.

A total of nine surface water samples were collected during the field sampling event. All proposed samples were collected with the exception of the deep surface water sample from Briar Lake. Consistent with the WPTM (Integral 2014a), the deep surface water sample was to be collected only if the water depth was greater than 2 feet. At the time of sampling the maximum water depth in the middle of the Briar Lake was approximately 18 inches, so collection of a deep water sample was not required.

2.6.1 Surface Water Sampling Modifications

Modifications to the surface water sampling locations were made during the field sampling event in order to capture potentially relevant information for surface water conditions. The following summarizes the rationale for modifications made to the proposed sampling locations.

- *Background Locations*: There was no standing water at any of the background locations (moist soils only) so no surface water samples were collected from any of these locations.
- *SW-HR14-05*: The sample location was moved slightly upstream to accommodate access on public lands.
- *SW-HR14-06 (*replaces *SW-BG14-01)*: The sample location for the upstream background, BG-01, contained no water therefore the sample was moved downstream where water was present. The new location is adjacent to the landfill and therefore this sample was identified as HR-06.
- *SW-BL14-05 (SW-BL14-03)*: The proposed surface water sample location at BL-05 was relocated to BL-03 in order to co-locate it with volatile organic samples collected by NJDEP.

Two additional surface water sample locations were added to the field sampling program in order to capture conditions observed on site the day of sampling. These were collected with the concurrence of the project coordinator (*de maximis inc*). Field crews observed a storm drain located near the HR-02 sampling location. Surface water samples at this location were taken at the confluence of Holly Run adjacent to the landfill and the storm drain from the neighboring residential area along Erial Road. One additional surface water sample was taken upstream at HR-01 to better characterize the conditions in the stream without the influence of the storm water drainage. A second additional surface water sample was taken at HR-03, just upstream of Briar Lake as a sediment sample could not be taken at this location.

The field duplicate for surface water sample was collected at location BL-01 and the matrix spike sample was collected at location HR-02.

2.7 SURFACE WATER SAMPLE RESULTS

The COPEC and non-COPEC metal results for total and filtered surface water samples are discussed below. The comparisons of the COPEC results to the surface water benchmarks are presented in Section 4. The field quality control samples consisted of a field duplicate and a field rinsate blank sample. The field duplicate sample was evaluated separately from the parent sample and treated as an independent sample for the data summaries. The field rinsate blank results are presented in Appendix D.

The COPEC Metal and Non-COPEC Metal surface water results are summarized in Tables 2-5a and 2-5b (total and filtered results, respectively). The dissolved organic carbon (DOC) results are shown on Table 2-5b. Sampling locations are shown on Figure 2-1. Individual sample results are presented in Appendix D.

2.7.1 Unfiltered (Total) Surface Water Metal Results

Four of the five COPEC metals were detected in the unfiltered (total) surface water samples from Holly Run or Briar Lake. Selenium was not detected in any of the unfiltered samples. The results for the remaining four COPEC metals are discussed individually below.

- *Arsenic*: Total arsenic was detected in one of the six Holly Run samples (HR14-04; 2.5 μg/L) and all four of the Briar Lake samples (range: 2 to 3.4 μg/L). The detected concentrations were similar between these two areas. The detection limit across all of these samples was 10 μg/L.

- *Cadmium*: Total cadmium was detected in three of the four Holly Run samples and in none of the Briar Lake samples. The Holly Run detections ranged from 0.33 to 0.41 μg/L. Cadmium was detected in the sample collected upstream of the landfill (SW-HR14-06) and in two of the samples (SW-HR14-01 and SW-HR14-03) that were collected downstream of the landfill but upstream of Briar Lake. Total cadmium was not detected in any of the Holly Run samples collected downstream of Briar Lake. The non-detect values ranged from 0.29 to 5 μg/L across the Holly Run and Briar Lake samples.

- *Iron*: Total iron was detected in all six of the Holly Run samples and in all four of the Briar Lake samples. This was not unexpected given the presence of iron flocculent or staining at many of the sample locations. The Holly Run detections ranged from 139 to 2,210 μg/L and the Briar Lake detections ranged from 2,300 to 11,000 μg/L. .

The Holly Run total iron concentrations varied spatially. The lowest relative total iron concentration was in the Holly Run sample collected upstream of the landfill (HR14-06; 139 μg/L). Total iron concentrations increased moving downstream from HR14-01 to HR14-03. Concentrations in Holly Run declined moving downstream from Briar Lake.

Total iron was also highly variable within Briar Lake. The higher relative dissolved iron concentrations were collected on the eastern half of the lake with the lowest relative concentration from the sample collected near the exit culvert (BL14-03), which also corresponded to the deeper portion of the lake.

- *Selenium*: Total selenium was not detected in any of the unfiltered surface water samples. The detection limit was 35 μg/L for all of the samples.

- *Zinc*: Total zinc was detected in one of the Holly Run samples and in none of the Briar Lake samples. The single detection in Holly Run (79 μg/L) was in HR14-06, which was on the GEMS property but upstream of the landfill. The non-detect values ranged from 1.1 to 8.5 μg/L in the Holly Run samples, and 4.8 to 50 μg/L in the Briar Lake samples.

Five of the non-COPEC metals (barium, beryllium, lead, mercury, and silver) were not detected in any of the unfiltered (total) surface water samples from either Holly Run or Briar Lake. Results for the remaining non-COPEC total metal results are presented in Appendix D.

2.7.2 Filtered Surface Water Metal Results

Lower concentrations were observed in the filtered samples compared to the unfiltered (total) samples for the COPEC metals (Table 2-5b). Four of the five COPEC metals were detected in the filtered surface water samples from Holly Run or Briar Lake. Selenium was not detected in any of the filtered samples.

- *Arsenic*: Dissolved arsenic was detected in two of the six Holly Run samples and in one of the four Briar Lake samples. The range of positive results was very narrow in Holly Run (2 to 2.2 μg/L) and the concentration was similar in the single positive result from Briar Lake (2.1 μg/L). The detection limit for the remaining samples was 10 U μg/L.

- *Cadmium*: Dissolved cadmium was detected in three of the six Holly Run samples and in none of the Briar Lake samples. The detected concentrations in Holly Run ranged from 0.27 to 0.34 μg/L. The maximum detection was in SW-D14-01, which was the field duplicate of SW-BL14-01; the latter had no detectable dissolved cadmium (detection limit of 0.3 U μg/L; Appendix Table D-4b). SW-HR14-03 was collected upgradient of Briar Lake and SW-HR14-04 was collected just downstream of Briar Lake. The detection limits ranged from 0.28 U to 5 U μg/L for the remaining three Holly Run samples and from 0.3 U to 5 U μg/L in the four Briar Lake samples.

- *Iron*: Dissolved iron was detected in all six of the Holly Run samples and in three of the Briar Lake samples. The Holly Run detections ranged from 25 to 1,330 μg/L with a mean concentration of 55 μg/L. The Holly Run dissolved iron concentrations varied spatially. The lowest relative dissolved iron concentration was in the Holly Run sample collected upstream of the landfill (HR14-06; 25 μg/L). Dissolved iron concentrations increased moving downstream from HR14-01 to HR14-03. Concentrations declined downstream from Briar Lake in the natural channel of Holly Run.

  Dissolved iron was also highly variable within Briar Lake, with the detected concentrations ranging from 106 to 763 μg/L, with a mean concentration of 408 μg/L. The higher relative dissolved iron concentrations were collected on the eastern half of the lake. The non-detect result was from the sample collected near the exit culvert (87 U μg/L; BL14-03), which also corresponded to the deeper portion of the lake.

- *Zinc*: Dissolved zinc was detected in only one of the six Holly Run samples and in none of the Briar Lake samples. The single detection in Holly Run (70.8 μg/L) was in SW-HR14-06, which was located upgradient of the landfill on GEMS property. The detection limits ranged from 0.57 U to 10.5 U μg/L for the remaining five Holly Run samples and from 2.3 U to 4.2 U μg/L in the four Briar Lake samples.

Six of the non-COPEC metals (barium, beryllium, lead, mercury, silver, and vanadium) were not detected in any of the filtered surface water samples from either Holly Run or Briar Lake. Results for the remaining non-COPEC filtered metal results are presented in Appendix D.

2.7.3 Surface Water Quality Parameters

Water quality measurements of temperature, pH, turbidity, conductance, dissolved oxygen and oxidation-reduction potential (ORP) were measured in the field at each surface water sample location. A YSI Inc. 6-Series multiparameter water quality sonde was used to measure these parameters. Additional information regarding the water quality parameters is discussed in the FSTM (Appendix C).

Surface water quality measurements were collected from six locations in Holly Run and three locations in Briar Lake. The results are summarized in Table 2-6 and the individual results are shown in Appendix Table D-5. The surface water quality parameter results are evaluated in Appendix D, and the key results are summarized below:

- *Conductivity:* The conductivity measurements were very similar across the sampling locations, ranging from 0.41 to 0.6 mS/cm in Holly Run and 0.46 to 0.57 mS/cm in Briar Lake.

- *Dissolved Oxygen:* The DO levels were highly variable across the sampling locations, ranging from 3.8 to 8.7 mg/L (42 to 92%) in Holly Run and 2.9 to 6.1 mg/L (32 to 62%) in

Briar Lake. The variation is likely due to water depth and whether the water was flowing or not at the time of sampling.

- *Field pH*: The field pH values were circumneutral across all of the sampling locations. Holly Run pH ranged from 6.71 to 7.28 while Briar Lake pH ranged from 6.89 to 7.08. There was no apparent association between field pH and location.

- *Oxidation/Reduction Potential (ORP)*: Field measured ORP was highly variable across the sample locations, although all but one location (HR14-02, -11 mV) were positive, indicating an oxidized system. The field log book (Appendix C) reported that the ORP reading in sample HR14-02 did not stabilize during the field monitoring.

- *Temperature*: The temperature measurements were fairly similar across the sampling locations, ranging from 14.1 to 18.3 °C in Holly Run and 15.1 to 18.2 °C in Briar Lake. On average, Briar Lake surface water was slightly warmer (17.1 °C) compared to Holly Run (15.9 °C). The variation in the temperature across the sampling location is likely related to several factors, including ambient temperature, the amount of canopy cover, and depth of the water at the sampling location. The daily air temperatures ranged from 15 to 22.8 °C (daily average ranged from 22.2 to 22.8 °C) during the sampling event[7].

- *Turbidity*: The turbidity measurements varied by location, with lower turbidly reported in the Holly Run samples (mean of 12.8 NTU, range of 6.7 to 22.7 NTU) compared to Briar Lake (mean of 32.8 NTU, range of 15.6 to 60.3 NTU). There was no apparent association between turbidity and location.

2.8 SEEP WATER AND ASSOCIATED SEDIMENT

As discussed in the WPTM (Integral 2014a), an option to collect seep water and the associated seep sediment was included in the field program if seeps were observed along the landfill slope at the time of sampling. No seeps were observed in October 2014 so therefore there were no seep water or seep sediments collected.

2.9 AGENCY CO-COLLECTED SAMPLES

As discussed in the FSTM (Appendix C), NJDEP co-collected samples from some of the sediment and surface water locations during the October 2014 field investigation for volatile organic compounds (VOC). For surface water, NJDEP personnel collected grab samples in 40-mL glass vials from the following locations for VOC analysis:

[7] Daily temperature data from the Mt. Holly, New Jersey, NWS Station: http://forecast.weather.gov/product.php?site=NWS&issuedby=PHL&product=CLM&format=CI&version=1&glossary=0

- Background Surface Water: BG-03 and BG-04
- Holly Run Surface Water: HR-05, HR-04, HR-03, and HR-02
- Briar Lake Surface Water: BL-01, BL-02, BL-3.

Integral did not observe NJDEP collecting field water quality measurements during their surface water sample collection operations.

For surface sediment, NJDEP personnel collected samples using a split-spoon core sampler for VOC analysis from the following locations:

- Background Sediment: BG-03, BG-04, and BG-05.
- Holly Run Sediment: HR-05, HR-04, HR-03 (subsurface only), and HR-02
- Briar Lake Sediment: BL-01, BL-02, BL-3

As these analyses are not part of this ERAGS Step 3 SMDP they are not summarized in this report and will be reported separately by NJDEP.

2.10 QUALITATIVE ECOLOGICAL ASSESSMENT

An initial site reconnaissance was performed on 21 March 2014 to support the development of the WPTM and determine what types of ecological receptors may be present or can utilize Holly Run and Briar Lake. This allowed the ecological risk assessors to become familiar with site features on a localized scale, identify other potential sources/inputs, check proximity of homes and potential for surface water flow from these properties to Holly Run and Briar Lake, and examine the physical features of Holly Run and Briar Lake.

As part of the October 2014 field investigation a qualitative ecological assessment was performed. EPA's Rapid Bioassessment Protocols (RBP; USEPA 1998, 1999a) and EPA's Superfund Biological Sampling Guidance Checklist for Ecological Assessment (USEPA, 1997b) were used as guides for this ecological assessment, which focused on four primary areas in the proximity of the sampling locations: Holly Run channel upstream of Briar Lake; Briar Lake; the natural channel of Holly Run downstream of Briar Lake; and the background locations.

The qualitative ecological assessment will be used to (1) assess habitat availability and determine what types of ecological receptors may be present or can utilize the four evaluated areas; (2) provide information on site features on a localized scale; (3) identify other potential sources/inputs; (4) determine proximity of homes and potential for surface water flow from these properties to Holly Run and Briar Lake, (5) examine the physical features of Holly Run and Briar Lake; and (6) support the evaluation of the Ecological ERAGS Step 3 SMDP.

The qualitative ecological assessment is presented in Appendix F. The key conclusions are summarized below.

- There was no suitable habitat for aquatic organisms within the rip-rap portions of Holly Run on the GEMS property. This is due to the lack of suitable sediment substrate in these areas. The exposed rip-rap shows evidence of iron staining and iron biofilm is present at some of the lower-lying areas of Holly Run.

- The entire length of the rip-rap channel of Holly Run on the GEMS property, with exception of a small portion near the western boundary of the property, is bounded by areas of grass or low brush maintained as part of the landfill closure. These have the potential to represent transit ways for terrestrial receptors but are unlikely to represent significant foraging areas.

- There is a small area (approximately 400 feet in length) of the Holly Run rip-rap channel on the northwest corner of the GEMS property that has a well vegetated boundary. This is also near an area that receives runoff from adjoining residential properties.

- There was no rooted aquatic or terrestrial vegetation within the rip-rap portions of Holly Run. Submerged attached green to dark green algae was observed in the natural channel of Holly Run downstream of Briar Lake. Emergent vegetation was not present in this flowing system.

- Rooted emergent aquatic vegetation, submerged filamentous vegetation, rooted floating vegetation and attached algae were observed throughout Briar Lake. Vegetation was dense under the surface of the lake and unvegetated sediments were present only on the margins of the lake. The submerged vegetation was coated with rust colored iron flocculent, which was easily dislodged when disturbed. The vegetation observed in Briar Lake and near the outfall suggests that there is sufficient epifaunal substrate available for colonization.

- Amphibians were observed in the portions of Holly Run with standing water (predominantly near Briar Lake), in Briar Lake, and downstream of Briar Lake in the natural channel of Holly Run.

- Multiple small minnow-sized fish (1-3 inches) were observed in the downstream natural channel of Holly Run just past the outfall from Briar Lake and at the other downstream location. A single similar fish was observed the upstream Holly Run channel just upstream of the outfall from the site to Briar Lake. The presence of fish was not observed in Briar Lake at the time of the field sampling.

- Other species observed in Holly Run downstream of Briar Lake included frogs and insect species. Turtles were not observed in this area at the time of sampling.

- A single Great Blue Heron was observed standing and wading in Briar Lake. Although waterfowls (ducks) were observed within Briar Lake during the March 2014 site visit, no waterfowl were observed during the October 2014 field investigation.

  Terrestrial birds were commonly observed in the wooded areas on the northwest portion of the GEMS property, near Briar Lake and downstream of Briar Lake. Hawks were observed flying above the capped landfill.

- The RBP observations showed that in general, the on-property portions of Holly Run provide minimal habitat for ecological receptors. Habitat conditions based on the RBP habitat assessment for a low gradient stream received a low score of 67, principally due to the absence of suitable substrate for colonization. In contrast, the natural channel portion of Holly Run downstream of Briar Lake had an RBP score of 138. These RBP results are not unexpected given the physical and hydrologic conditions of these areas. The RBP was not relevant to non-flowing waterbody (i.e., Briar Lake).

In summary, there is minimal ecological habitat in the rip-rap channel of Holly Run, particularly in the landscaped portion of the property. Ecological habitat for aquatic species greatly improves in the natural channel of Holly Run downstream of Briar Lake. Briar Lake exhibits extensive aquatic plant development. The sediment surface exhibits a loose iron flocculent layer which is easily disturbed. This does not appear to be impacting the growth of epibenthic algae or the presence of aquatic species (e.g., amphibians in the lake).

2.11 REVIEW OF OTHER AVAILABLE ANALYTICAL DATA

One of the underlying assumptions from the Agencies is that the chemicals with concentrations above screening values in the site sediments originated from passive discharge of untreated groundwater leachate between the implementation of the Phases I and II remedial measures. No active monitoring of leachate is known to have been conducted during the interim period between these two phases.

To assess this for the five metals identified by EPA in their June 2013 letter, a review of the available historical and current groundwater sample results to determine whether these metals are present and their relative concentrations was performed. This data was collected by other entities and was provided by *de maximis* to Integral for this analysis.

2.11.1 Review of Groundwater Data Near Holly Run

The GEMS Trust Project Coordinator (*de maximis*) maintains a database of the groundwater results collected since 2005 (i.e., after implementation of the Phase II remedial measure). There are five piezometers (PM-12, PM-18, PM-19, PM-24, and PM-25) that are screened in the Upper Cohansey Aquifer that are located near Holly Run (Figure 2-2). Analytical data are available

from September 2005 through June 2014 for most of the COPEC metals, although samples were not collected from all of these piezometers across this period. The results for the five COPEC metals are summarized by piezometer in Table 2-7 and are discussed below. Figure 2-3 shows the temporal variation in COPEC concentrations for the detected COPEC metals. For this figure the non-detect results (most commonly observed for arsenic and zinc) were plotted as one-half the reported detection limit.

Arsenic

- Arsenic was not detected in PM-18, which was the deepest of the evaluated piezometers. It was detected with an approximate frequency of 50% in PM-12 (8 of 14 samples), PM-24 (6 of 13 samples) and PM-25 (6 of 14 samples) across all of the sampling events. It was detected in all 13 samples collected from PM-19.

- The highest average concentration for arsenic (112 µg/L) was in PM-19, which is located upstream of the perforated pipe section of the Holly Run underdrain. This piezometer also had the maximum reported arsenic concentration (230 µg/L) across all of the piezometers and sampling dates. The maximum arsenic concentration was reported from PM-19 on two dates (September 2005 and July 2006).

- The remaining three piezometers had similar average arsenic concentrations (3 to 3.3 µg/L) and overall range of detections, suggesting that these likely represent regional levels for arsenic near the GEMS property.

- Review of Figure 2-3 shows that arsenic concentrations peaked at different times across the piezometers. All piezometers except PM-19 vary within a similar concentration range.

Cadmium

- Cadmium was not detected in any of the shallow groundwater piezometer samples.

Iron

- Iron was detected in all of the piezometers and across all of the sampling events. Iron concentrations varied across the sampling events for individual piezometers, and also between piezometers.

- The highest average iron concentration was in PM-19 (74,175 µg/L), followed by PM-12 (30,840 µg/L), PM-25 (7,515 µg/L) and PM-24 (4,224 µg/L).

- The maximum concentration across all piezometers and sampling events was in PM-19 (95,200 µg/L), collected in April 2011.

- The lowest concentration for iron was in the single sample collected from PM-18 (146 μg/L). This piezometer is located northeast of the GEMS property.

- Review of Figure 2-3 shows that iron concentrations peaked at different times across the piezometers, although there is a limited number of results (4) for most piezometer location which makes it difficult to discern a clear temporal trend.

Selenium

- Selenium was not detected in any of the shallow groundwater piezometer samples.

Zinc

- Zinc was not detected in PM-18, which was the deepest of the piezometers near Holly Run. It was detected with an approximate frequency of 50% in PM-12 (2 of 5 samples) and PM-19 (2 of 5 samples). It was detected in all of four samples collected from PM-24 and PM-25.

- The highest average concentration for zinc (187 μg/L) was in PM-25, which is located near the Erial Road entrance to the GEMS property. This piezometer also had the maximum reported zinc concentration (440 μg/L) across all of the piezometers and sampling dates. The maximum zinc concentration was reported in the sample from September 2005.

  PM-25 also exhibited widely varying detections for zinc. Concentrations ranged from 17.4 to 440 μg/L (factor of 25 times) across the four sampling events for this piezometer.

- Two piezometers (PM-12 and PM-19) had similar average zinc concentrations (12 and 10.4 μg/L, respectively).

- Review of Figure 2-3 shows that zinc concentrations peaked at different times across the piezometers, although there is a limited number of results per location to discern a clear temporal trend.

In summary, PZ-19 had the highest concentration of two of the five COPEC metals (arsenic and iron), and PZ-25 had the highest concentration of zinc, relative to the other piezometers located near Holly Run. Cadmium and selenium were not detected in any of the evaluated piezometer samples.

2.11.2 Review of Holly Run Underdrain Data

Sampling of the influent from the Holly Run Underdrain for VOCs, Semivolatile organics, inorganics and general parameters was performed monthly from August through December

2002. There has been no additional sampling for inorganics since that period. These influent samples are from a passive drain system that was put into service in approximately 1994, which is prior to the Phase I site remediation. The limited inorganic and general parameter results (2002 data only) are shown in Table 2-8. It was assumed that these represented total inorganic results.

Results for many of the TAL inorganics were not reported. However, data were available for three of the COPEC metals - arsenic, iron and zinc. All three of these COPECs were detected in all four samples (inorganics were not evaluated in the initial sampling event in August 2002). The ranges of the results for these three parameters were within the ranges observed in the piezometers that were sampled beginning in 2005 (Table 2-7).

2.11.3 Review of Treated Groundwater and Condensate Data

Since 2005 the treated groundwater and treated condensate from the gas wells[8] have been discharged to the public treatment works. The GEMS Phase II Trust provides quarterly reports to EPA on the status of the Phase I remediation operation and maintenance. These reports also include a summary of the Industrial Discharge Monitoring Reports (IDMRs) that are submitted to CCMUA which receives the pre-treated discharge from the landfill.

IDMR reports were first prepared when the discharge to the public treatment works began (July 2005) and are updated on a monthly basis. The discharge permit requirements were modified in 2009 pursuant to a Court Order. The most recent requirements include monitoring of VOCs, SVOCs, BTEX, ten metals, cyanide, phenol, sulfide, pH, flow, COD, BOD, TSS, oil and grease, petroleum hydrocarbons, total dissolved solids, total toxic organics, gross alpha, gross beta, and Radium-226/228.

The IDMRs report the permit requirements and observed results. Total (i.e., unfiltered) metals are analyzed from 24-hour composites collected once every other week. The table below summarizes the permit requirements for the five COPEC metals and observed results (units are mg/L) from the latest available IDMR report (October 2014)[9].

[8] This was identified as treated groundwater and leachate in the WPTM (Integral 2014a), but is updated herein.

[9] The October 2014 IDMR is available from the following URL: http://www.gemssuperfundsite.org/Documents/CCMUA_IDMROct14.pdf

COPEC Metal	Permit Limit	Observed Results
Arsenic	1	<0.1
Cadmium	0.04	<0.01
Iron	---	---
Selenium	---	---
Zinc	4	<0.1

None of the COPEC metals with permit requirements were detected and the detection limits were all below the permit requirements. There were no permit requirements for either iron or selenium. The review of the last few quarters of discharge monitoring showed that none of the COPEC metals were detected in any of the samples.

3 PROBLEM FORMULATION

ERAGS Step 3 is the Problem Formulation step of the EPA BERA process, which includes refinement of COPECs, toxicity evaluation, development of a site conceptual model and exposure pathways, and development of assessment endpoints. This step includes an SMDP.

3.1 REFINING CONTAMINANTS OF ECOLOGICAL CONCERN

The SLERA prepared by EPA (equivalent to ERAGS Steps 1 and 2) formed the basis of the identification of the Contaminants of Potential Ecological Concern (COPECs). Table 1-1 summarizes the COPECs that were identified in the EPA SLERA. In Holly Run, the COPECs included four metals, one VOC (acetone) and two SVOCs (acenaphthene and naphthalene). For Briar Lake, the COPECs included nine metals, two VOCs (acetone and chlorobenzene) and one SVOCs [Bis(2-ethylhexyl) phthalate]. Of these, the EPA letter of June 20, 2013, specifically mentions concentrations of cadmium, arsenic, iron, selenium and zinc in sediment exceeded ecological benchmarks and background value, as a basis for performing the BERA. The WPTM (Integral 2014a) included a refined screen of these chemicals, which concluded that none of the organics originally identified as SLERA COPECs would require further evaluation as part of the ERAGS Step 3 assessment.

No further refinement of the COPECs will be performed as part of this ERAGS Step 3 assessment. The uncertainty section (Section 4.3) addresses questions raised by EPA regarding the WPTM screening out of two organics detected in the 2006 sediment samples (chlorobenzene and naphthalene) and chemicals that were not detected in these samples but which had elevated detection limits (2,4-dinitrophenol, 4-nitrophenol, hexachlorocyclopentadiene, 2-methylphenol and carbon disulfide). This re-assessment was requested by EPA following approval of the WPTM.

3.2 POTENTIAL FATE AND TRANSPORT MECHANISMS

The WPTM (Integral 2014a) discussed the potential fate and transport mechanisms that likely exist at the site and downstream in Briar Lake. Briefly, these include (1) surface runoff from the GEMS landfill cap; (2) discharge of treated groundwater and leachate to the CCMUA; (3) absence of sediment transport out of Briar Lake to downstream portions of Holly Run (except possibly as suspended solids under certain high-flow conditions); and (4) anthropogenic inputs (e.g., roadway surface runoff) into Briar Lake and Holly Run.

The CSM update includes the identification of potential additional inputs to Briar Lake and Holly Run. Details related to the site hydrogeology are being addressed by other consultants

for this project, in work that is being prepared independently of, and not directly relevant to, the ERAGS Step 3 Assessment.

There are three additional transport pathways that were evaluated subsequent to the development of the WPTM. These include the following:

- Potential inputs from off-property areas
- Potential for COPEC Uptake by Aquatic Plants
- Potential for COPEC Uptake by Aquatic Invertebrates

These are discussed below.

Potential Inputs from Off-Property Areas

As discussed in the FSTM (Appendix C) a storm drain located just upgradient of HR-02 receives runoff from adjacent residential properties and Erial Road. At the time of the October 2014 field investigation this storm drain appeared to be the main source of flowing water from location HR-02 downstream to the confluence of the Holly Run rip-rap channel and Briar Lake. Surface water upgradient of the storm drain at HR-01 was stagnant and far shallower than the channel downgradient of the storm drain.

Table 3-1 compares the COPEC metal results for surface water collected at HR-02 and HR-01. Arsenic, selenium and zinc were not detected at either location as total or dissolved metals. Cadmium was detected in SW-HR14-01 and not SW-HR14-02, but the detected concentration was close to the reporting limit. Higher concentration (factor of approximately 2.5 times) for total or dissolved iron was reported in SW-HR14-02 compared to SW-HR14-01. This result suggests that, at least for iron, there is the potential for off-property inputs.

Potential for COPEC Uptake by Aquatic Plants

The potential for uptake of the COPEC metals from sediments to plants is expected to be quite low. For example, Baes et al (1984) reports the ratios of vegetation to soil concentrations (B_v; both in dry weight) are less than one for nearly all of the COPEC metals, except for zinc (Table 3-2).

Although these values were developed for terrestrial systems, they are often extended to aquatic systems (e.g., USEPA 1999b) since there is typically little empirical data available for aquatic plant uptake from sediments. The default value for zinc recommended by Baes et al (1984) suggests that there is the potential for accumulation of zinc by plants. Fritioff and Greger (2006) reported that zinc can be accumulated in the roots of the *Potamogeton natans* (broad-leaved pondweed) but there was little translocation into the vegetative portions of the plant.

Therefore, it is unlikely that the sediment-bound metals can represent an indirect exposure pathway for herbivores based on plant consumption.

Potential for COPEC Uptake by Aquatic Invertebrates

Similarly, the potential for uptake of the COPEC metals from sediments to aquatic invertebrates is expected to be quite low. For example, the Sediment-To-Benthic Invertebrate Bioconcentration Factors reported in USEPA (1999b) are less than one for all of the COPEC metals, except for cadmium (Table 3-2). Cadmium was not evaluated further since the observed sediment concentrations were comparable to background (Section 4.2).

Based on this assessment, it is unlikely that there is any significant uptake of the COPEC metals into forage or prey of higher trophic level organisms that may be present in the vicinity of the site.

3.3 CONCEPTUAL SITE MODEL UPDATE

A Preliminary Conceptual Site Model (pCSM) was presented in the WPTM (Integral 2014a). This was based on previously collected information (in 2006) and observations that were made during the March 2014 site visit that identified potentially complete exposure pathways and potential receptor groups. The principal exposure routes for ecological receptors are via direct pathways (e.g., direct contact of sediments) and indirect pathways (ingestion of prey that may bioaccumulate COPECs from sediments or surface water).

The CSM is meant to be an evolving model for potential transport mechanisms and exposure routes. Therefore, the pCSM was re-evaluated and updated based on results from the October 2014 field investigation (Figure 3-1). As was observed during the 2006 sampling program and the March 2014 site reconnaissance, there is minimal sediment substrate within the on-property Holly Run rip-rap channel, and therefore these areas are unlikely to represent a source of exposure to sensitive ecological receptors, such as benthic invertebrates. The following adjustments were made to the pCSM transport pathway and evaluated receptors based on the observations made during the 2014 field investigation.

Transport Pathways

- A storm drain located just upgradient of sample location HR-02 receives runoff from adjacent residential properties and Erial Road. Comparison of the COPEC metal results for the surface water samples downstream and upstream of this location suggested that for at least the COPEC iron there is the potential for off-property inputs.

- Storm drains located on Primrose Lane appear to be discharging to Briar Lake. Based upon review of the construction design drawings for Briar Lake, there is also a surface runoff drain to the lake on the south side.

- There is significant sediment accumulation in Briar Lake. Based upon review of the construction design drawings, the original excavation depth in Briar Lake was approximately 2-ft below the top of water column (Figure 3-2). Although the elevation of the water column at the time of sampling was not collected, it was readily apparent that most of Briar Lake had water depths far less than 2-ft (e.g., approximately 6 inches at the easternmost location near the entry culvert from Holly Run). The sedimentation is most apparent on the east side of the lake near the Holly Run discharge.

Evaluated Receptors

The WPTM (Integral 2014a) identified benthic invertebrates and amphibians for evaluation as part of ERAGS Step 3. Although not evident during the early spring (March 2014) site visit, frogs were observed and/or heard jumping into the water upon approach in all four areas of investigation: on-site Holly Run, Briar Lake, downstream Holly Run, and background locations.

Based on observations made during the October 2014 field investigation the following additional receptors will be evaluated as part of ERAGS Step 3:

- *Fish*: Fish were originally not included as a receptor of interest in the WPTM (Integral 2014a) since none were observed during the March 2014 site visit. Fish were not observed in Briar Lake (along the shoreline or from sampling locations using the boat or while wading) during the October 2014 field investigation[10]. However, as discussed in the FSTM (Appendix C), small minnow-sized fish were observed in the Holly Run downstream of Briar Lake (HR-04) and a single fish was observed at HR-03 upstream of Briar Lake.

  Based upon the observations from the October 2014 sampling event the potential impacts from waterborne exposure will be evaluated for this receptor group in the Holly Run downstream of Briar Lake.

- *Waterfowl/Aquatic Birds*: Ducks were observed on Briar Lake during the March 2014 site visit, although no ducks were present during the October 2014 field investigation. However, a great blue heron was observed wading in Briar Lake. The single heron did not attempt any prey capture behavior during observation, but it is likely that prey are foraged from Briar Lake or downstream in Holly Run by wading birds. Small fish were

[10] Bubbles were observed rising to the surface in Briar Lake during the sampling which could be interpreted as evidence of fish activity but this was more likely related to microbial activity because there was no evidence of bubble trails typical of fish movements.

observed in Holly Run downstream of Briar Lake which likely serve as prey for piscivorous birds, like the heron.

Therefore, the CSM was modified to assess potential exposure to sediments (via incidental ingestion) and prey by herons in Briar Lake and Holly Run downstream of Briar Lake.

The WPTM (Integral 2014a) included an option to assess reptiles. During the October 2014 field investigation there was no evidence of use of Briar Lake or Holly Run by reptiles. The habitat in Briar Lake and the portions of Holly Run near the GEMS property are not ideal for reptiles. Exclusion of this receptor group will be evaluated as part of the Uncertainty Assessment.

3.4 IDENTIFYING ASSESSMENT AND MEASUREMENT ENDPOINTS TO SUPPORT THE ERAGS STEP 3 EVALUATION

The primary objective of developing appropriate assessment and measurement endpoints is to frame the risk evaluation to be performed as part of the quantitative ERA and to relate potential risk management decisions into the risk evaluation process.

Assessment Endpoints are statements of the characteristics or attributes of the environment that are to be protected.

Measurement Endpoints are a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. They can include measures of effect and/or measures of exposure.

Aquatic species, such as fish and amphibians, and semi-aquatic avian species that may utilize portions of Holly Run and Briar Lake as foraging areas have the potential to contact the COPECs present in the media. Such potential exposures may occur through direct contact to the environmental media or from indirect contact through the consumption of biota that may have been exposed to sediment or surface water containing these chemicals. The COPECs are all metals that exhibit low potential for significant bioaccumulation in prey or forage. Therefore for the assessment of dietary exposures the primary exposure media are sediments and surface water. The assessment endpoints and measurement endpoints have been summarized below.

Assessment Endpoint No. 1: Evaluate the potential for adverse effects on benthic macroinvertebrates that can serve as a potential prey base for higher trophic level species resulting from exposure to COPECs in sediment and surface water.

The measurement endpoints used to determine whether or not there is an adverse impact to benthic macroinvertebrate populations includes the following:

- Measurement Endpoint 1-1: Compare observed sediment concentrations to suitable benchmarks (e.g., sediment quality guidelines [SQG) to determine potential for adverse effects to benthic populations.

- Measurement Endpoint 1-2: Perform an analysis of potential COPC bioavailability to benthic macroinvertebrates (i.e., evaluation of AVS/SEM results).

Assessment Endpoint No. 2: Evaluate the potential for adverse effects (survival, growth, or reproduction) to local amphibian populations resulting from exposures to COPECs in sediment and surface water.

The measurement endpoints used to determine whether or not there is an adverse impact to the local amphibian populations are the following:

- Measurement Endpoint No. 2-1: Compare observed sediment concentrations to suitable benchmarks to determine potential for adverse effects to amphibians.
- Measurement Endpoint No. 2-2: Compare observed filtered surface water concentrations to suitable benchmarks (e.g., surface water quality criteria) to determine potential for adverse effects to amphibians.

Assessment Endpoint No. 3: Evaluate the potential for adverse effects (survival, growth, or reproduction) to fish species resulting from exposure to COPECs in surface water and sediments.

The measurement endpoints used to determine whether or not there is an adverse impact to the fish species are the following:

- Measurement Endpoint No. 3-1: Compare filtered constituent concentrations in surface water to New Jersey surface water quality criteria, Federal ambient water quality criteria (AWQC), or other relevant criteria to determine potential for adverse effects to amphibians.
- Measurement Endpoint No. 3-2: Compare the distribution of filtered constituent concentrations in surface waters with the range of no significant effect concentrations for growth and reproduction for water column fish.

Assessment Endpoint No. 4: Evaluate the potential for adverse effects (survival, growth, or reproduction) to local upper trophic level herbivorous avian populations resulting from exposures to COPECs in sediments, surface water, and/or forage.

The measurement endpoints used to determine whether or not there is an adverse impact to the upper trophic level herbivorous avian populations include the following:

- Measurement Endpoint No. 4-1: Compare the back-calculated sediment ingestion benchmarks (SIBs) to observed media concentrations using the average daily doses (ADDs) and TRVs for COPEC metals for this avian receptor.

Assessment Endpoint No. 5: Evaluate the potential for adverse effects (survival, growth, or reproduction) to local upper trophic level piscivorous avian populations resulting from exposures to COPECs in sediments, surface water, and/or prey.

The measurement endpoint used to determine whether or not there is an adverse impact to the upper trophic level piscivorous avian populations is the following:

- Measurement Endpoint No. 5-1: Compare the back-calculated SIBs to observed media concentrations using the average daily doses (ADDs) and TRVs for COPEC metals for this avian receptor.

4 ERAGS STEP 3 RISK CHARACTERIZATION

The risk characterization that is presented in this section is similar to but not as refined as that performed in ERAGS Step 7. For example, a detailed review of the underlying studies for deriving the avian TRVs was not performed. Instead, the recommended TRV-NOAEL values from the EPA EcoSSL documents were used, when available. Risk characterization typically involves three principal components: (1) risk estimation, (2) risk description, and (3) uncertainty analysis.

4.1 REFINED ECOLOGICAL BENCHMARKS

As discussed early, the EPA SLERA used the SERAS software which compared the individual sediment sample results from 2006 to conservative (low) benchmarks. This approach is consistent with the initial screening step of the BERA process. For this assessment, a more refined set of benchmarks were used for evaluating the sediment and surface water results.

4.1.1 Sediment Benchmarks for Assessing Benthic Invertebrates

For the assessment of potential impacts to benthic invertebrates, the surface sediment results were compared to several benchmarks. These included (1) the NJ sediment criteria (NJDEP 2009); (2) consensus sediment criteria (MacDonald et al 2000); (3) site-specific background concentrations, and (4) regional concentrations from the historical USGS National Uranium Resource Evaluation (NURE) dataset for sediments collected from New Jersey (Smith 2006). These are discussed below and compiled in Table 4-1.

NJ Sediment Criteria: The acute and chronic NJ sediment criteria are compiled in NJDEP (2009). The sediment criteria include Lowest Effects Levels (LELs) and Severe Effects Levels (SELs). LELs represent concentrations that are tolerated by most benthic organisms. SELs represent concentrations where severe impacts to the benthic community have been identified.

Consensus Sediment Criteria: These values were based upon a review of existing sediment quality guidelines performed by MacDonald and co-workers (2000). Threshold effect concentrations (TECs) and a probable effect concentration (PECs) were calculated as the geometric means across the threshold and probably effect sediment benchmarks (respectively). Many of the NJDEP LEL values are consistent with the Consensus Sediment TEC values.

USGS NURE Sediment Dataset for New Jersey: Appendix G describes the USGS NURE sediment dataset for New Jersey. Although these represent older samples (late 1970s) they provide useful information regarding the range of regional concentrations that would be present in New Jersey on a state-wide basis. The State of New Jersey developed regional

background concentrations for soils (Sanders 2003) but a comparable database has not yet been developed for sediments. Surface sediment results for samples collected from stream water depths of less than or equal to 0.5 foot (the minimum water depth reported) were used since these are consistent with the water depths of Holly Run and Briar Lake.

4.1.2 Surface Water Benchmarks

For the assessment of potential impacts to aquatic species, the surface water results were compared to several benchmarks. These included (1) the NJ surface water criteria (NJDEP 2009); (2) EPA ambient water quality criteria; (3) 20% Effect Concentration (EC_{20}) values reported by Suter and Tsao (1996) for trout and daphnids; and (4) the geometric mean of the no effect water concentrations for growth, reproduction and survival of fish reported in the EPA ECOTOX database. Generally, filtered surface water results are most relevant from an ecological perspective, but these comparison were also made to unfiltered results. The surface water benchmarks are compiled in Table 4-2, and are discussed below.

NJ Surface Water Criteria: The acute and chronic NJ surface water criteria are compiled in NJDEP (2009). Several of the NJ surface water criteria are hardness-dependent. The sample-specific hardness in the samples was calculated using the following equation[11]:

$$Hardness\ \left(\frac{mg}{L}\right) = \left(2.497x\left[Calcium\ Conc, \frac{mg}{L}\right]\right) + (4.118x\left[Magnesium\ Conc, \frac{mg}{L}\right])$$

The supporting calculations for the hardness-dependent NJ water quality criteria are provided in Appendix H (Tables H-1a and H-1b for dissolved and unfiltered water samples, respectively). Hardness was calculated for both the unfiltered and filtered surface water results, although this yielded similar results on a sample-specific basis.

EPA Ambient Water Criteria: The EPA ambient water quality criteria for the protection of aquatic life were obtained on-line[12]. The freshwater Criteria Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC) were used. The CMC is the acute criterion, and is the chemical concentration in surface water that an aquatic community can be briefly exposed without resulting in an unacceptable effect. The CCC is the chronic criterion, and is the chemical concentration in surface water that an aquatic community can be exposed indefinitely without resulting in an unacceptable effect. The hardness-dependent values were calculated in the same manner as the NJ surface water criteria, except the EPA equation parameters were used.

Suter and Tsao (1996): These authors compiled summary tables of the lowest chronic values (LCVs) and EC_{20} values in surface water for aquatic species, including fish and invertebrates.

[11] From Standard Methods, Method 2340. Available from http://edge.pondev.com/wp-content/uploads/Inorganic_SM2340.pdf

[12] These were from the following URL: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

The EC_{20} values for fish represents the concentration causing less than 20% reduction in (1) the weight of young fish per initial female fish in a lifecycle or partial life-cycle test or (2) the weight of young per egg in an early life-stage test. The EC_{20} values for daphnids the concentration causing less than 20% reduction in the product of growth, fecundity, and survivorship in a chronic test with a daphnid species.

EPA ECOTOX Database: The ECOTOXicology database (ECOTOX) is an on-line resource of chemical toxicity data for aquatic life, terrestrial plants and wildlife that is maintained by the EPA[13]. For the ERAGS Step 3 assessment, the database was queried to summarize the no effect surface water concentrations for growth, reproduction and survival effects in fish. Details regarding the data queries are provided in Appendix H. The geometric means of the no effect concentrations will be used as the benchmarks for comparison against the observed surface water results.

4.1.3 Sediment Ingestion Benchmarks

For the two avian receptors, the COPEC metal Sediment Ingestion Benchmark (SIB; mg/kg_{dw}) are calculated by inverting the standard average daily dose (ADD) equation used in later Steps of the ERAGS process and replacing the ADD term with the toxicity reference value (TRV). The equation is shown below.

$$SIB = \frac{TRV\ x\ BW}{SUF\ x\ AUF\ x\ IR_{sed}}$$

Where

SIB	=	sediment ingestion benchmark (mg/kg_{dw})
TRV	=	toxicity reference value (mg/kg-day)
IR_{sed}	=	daily ingestion rate of sediment (kilograms per day [kg/day])
AUF	=	area use factor (unitless)
SUF	=	seasonal use factor (unitless)
BW	=	body weight (kilograms [kg]).

The COPEC-specific SIB values are then compared to the observed sediment concentrations to determine whether sediment ingestion represents a potential ecological risk to the avian receptors. The input terms are discussed below and summarized in Tables 4-3 and 4-4.

[13] The ECOTOX database can be accessed from this URL: http://cfpub.epa.gov/ecotox/advanced_query.htm

4.1.3.1 Avian TRV Values

No observable adverse effect level (NOAEL) TRVs were obtained from multiple sources, as described below, and are summarized in Table 4-3.

- *Arsenic*: The avian TRV-NOAEL was 2.24 mg/kg-day as reported in the arsenic EcoSSL document (USEPA 2005a). This is the lowest NOAEL value for reproduction, growth, or survival.

- *Cadmium*: The avian TRV-NOAEL of 1.47 mg/kg-day as reported in the cadmium EcoSSL document (USEPA 2005b). The TRV is equal to the geometric mean of NOAEL values for reproduction and growth.

- *Iron*: The EPA EcoSSL document does not include a recommended TRV-NOAEL for iron (USEPA 2003). The avian TRV-NOAEL of 41.7 mg/kg-day was derived from an iron tolerance study by McGhee et al. (1965), as reported in NAS (1980). McGhee et al. (1965) exposed day old chicks for 28 days to a diet containing iron sulfate and monitored growth. Three dietary dose levels (400, 800 and 1,600 ppm) were used, and the iron was in the form of iron sulphate, which was highly bioavailable. There were no adverse effects at the 400 ppm dose level, but there was reduced growth at the higher dose levels when copper was limiting[14]. Based on a body weight of 0.121 kg and food consumption rate of 0.0126 kg/d [values for 14-day old chicks reported by Sample et al (1996)], this 400 ppm dietary dose level equates to a TRV-NOAEL of 41.7 mg/kg-d.

  This value is likely an underestimate of the iron TRV-NOAEL because (1) the study used a highly bioavailable form of iron; (2) the concentration of iron in the basal diet was not used to derive the TRV-NOAEL; and (3) it also assumes that copper is limiting in the diets of the birds at the site.

- *Selenium*: The avian TRV-NOAEL of 0.29 mg/kg-day as reported in the cadmium EcoSSL document (USEPA 2007a). This TRV is equal to the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth or survival.

- *Zinc*: The avian TRV-NOAEL of 66.1 mg/kg-day as reported in the zinc EcoSSL document (USEPA. 2007b). This TRV is equal to the geometric mean of NOAEL values within the reproduction and growth effect groups.

The NOAEL TRVs were selected for conservatism.

[14] In their interpretation of this study, FWS reported that there were no ill effects on chickens fed 1,600 ppm iron in an adequate diet." See http://www.gpo.gov/fdsys/pkg/FR-2004-03-15/html/04-5782.htm

4.1.3.2 Incidental Ingestion Rate of Sediments by Avian Receptors

Incidental ingestion rates for the avian species were based on allometric equations and the body weights of the representative receptors (Table 4-4). These are summarized below by receptor:

- The mallard duck incidental sediment ingestion rate is 0.36 g_{dw}/d. This was calculated by multiplying the dry weight food ingestion rate by 2%; the latter is the default ratio of food to dry weight sediment ingestion rate reported by Beyer et al. (1994). The dry weight food ingestion rate was calculated using the allometric equation for non-Passerine birds from Nagy (1987) and the average body weight for mallard ducks (1.415 kg from USEPA (1993). The fresh weight food ingestion rate calculated by this equation is converted to dry weight by multiplying by 0.3.

- The Great Blue Heron incidental sediment ingestion rate is 8.22 g_{dw}/d. This was calculated by multiplying the dry weight food ingestion rate by 2%, as was done for the mallard duck. The fresh weight food ingestion rate was calculated using the using the equation from reported for wading birds by Kushlan (1978) and the average body weight (2.34 kg) from USEPA (1993). The fresh weight food ingestion rate calculated by Kushlan equation is converted to dry weight by multiplying by 0.3.

4.1.3.3 Area Use Factor

Area Use Factors (AUFs) were calculated as the fraction of the receptor's home range that is represented by the available habitat in Briar Lake. The total area of open water in Briar Lake is 0.9 acres, based on the aerial photograph used as a base map for the GIS figures included in this report. The home ranges are literature values and are summarized below.

- The mallard duck home range is 580 acres (1,432 acres) which was the average for both genders reported in USEPA (1993).

- The Great Blue Heron home range is 4.5 hectares (11.1 acres), as reported in USEPA (1993).

The calculated AUFs were 0.00063 and 0.081 for the mallard duck and Great Blue Heron, respectively, for Briar Lake and Holly Run combined.

4.1.3.4 Seasonal Use Factor

The Great Blue Heron is considered to be a year round resident in New Jersey[15] while the mallard duck is considered a migratory species. The Seasonal Use Factor (SUF) reflects that portion of the year when Briar Lake may be used for foraging or shelter by the evaluated

[15] Based on information from this URL:
http://www.conservewildlifenj.org/species/fieldguide/view/Ardea%20herodias/

receptors. This parameter can reflect both ecological (e.g., migratory habits of the evaluated receptors) and abiotic components (e.g., loss of access to the lake areas during the winter months when the lake is frozen).

For the heron it was assumed that Briar Lake would be utilized from March through December (ten months, equivalent to an SUF of 0.83), given that the lake is likely frozen or partially frozen in January and February. The mallard duck was conservatively assumed to utilize Briar Lake from March through October (eight months, equivalent to an SUF of 0.67). This is likely conservative for both species since (1) mallard ducks were observed resting at Briar Lake only during the March 2014 site visit and were not observed or heard during the October 2014 field investigation; and (2) a single heron was observed in Briar Lake only during the November field investigation.

4.2 ERAGS STEP 3 RISK ESTIMATION

The risk estimation component includes qualitative and quantitative summaries of the exposure assessment results (including information from wildlife exposure models and field investigations). Similar to the approach taken in the EPA SLERA, potential risks for benthic invertebrates, fish and amphibians were estimated using the hazard quotient (HQ) method. The HQ approach is based on the comparison of the observed media concentrations (sediment or dissolved surface water concentrations) to relevant benchmarks, using the following equation:

$$HQ = \text{Media Concentration} \div \text{Benchmark}$$

For the ERAGS Step 3 assessment, the benchmarks typically represent no effect levels. When the HQ is less than benchmark, a potential risk does not exist. When the HQ is greater than 1.0, the estimated potential exposure exceeds the benchmark and a potential risk may exist, albeit above a no effect level. HQs are non-linear since they are not dose-response based *per se*, but rather are based on a threshold value. When the HQ is greater than one a more detailed evaluation of the potential risks are performed.

The primary focus of the risk estimation is on the COPEC metals although an assessment of the non-COPEC metals is also performed.

4.2.1 Assessment Endpoint No. 1 (Benthic Invertebrates)

Assessment Endpoint No. 1 assesses the potential effects on benthic macroinvertebrates as a potential prey base for higher trophic level species resulting from exposure to chemicals in sediment and surface water. Two measurement endpoints have been evaluated for this assessment endpoint. Figure 4-1 shows the spatial distribution of the sediment COPEC metals and their corresponding refined benchmarks used to evaluate the results.

Measurement Endpoint No. 1-1: Comparison of sediment concentrations with effects concentrations (e.g., NJDEP ESCs, SQGs)

The comparisons to the sediment benchmarks are made by sampling area and COPEC metal.

COPEC Metal Results in Briar Lake

The results for the five COPEC metal results from Briar Lake are summarized below and compared to NJDEP Ecological Screening Criteria (NJDEP 2009) and alternate sediment benchmarks in Table 4-5.

- *Arsenic*: Arsenic was detected in all six Briar Lake samples with an average concentration of 42 mg/kg$_{dw}$ (range: 9 to 72.8 mg/kg$_{dw}$). The average and maximum concentrations were both above the NJDEP LEL and SEL values (9.98 and 33 mg/kg$_{dw}$, respectively) for arsenic. One of the Briar Lake samples (SED-BL14-01) was below the LEL and three (SED-BL14-01, SED-BL14-01 Dup, and SED-BL14-05) were below the SEL.

  The arsenic results in all of the Briar Lake samples were also greater than the maximum site background sample (3.2 mg/kg$_{dw}$) and all samples but SED-BL14-01 were also above the USGS NURE maximum background sample (16 mg/kg$_{dw}$).

- *Cadmium*: Cadmium was detected in all six Briar Lake samples with an average concentration of 0.9 mg/kg$_{dw}$ (range: 0.37 to 1.4 mg/kg$_{dw}$). The maximum concentration was observed in SED-BL14-03, which was collected near the exit culvert of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run.

  The average cadmium concentration was slightly above the NJDEP LEL value (0.6 mg/kg$_{dw}$) and three of the six samples were greater than the NJDEP LEL, and all six samples were below the NJDEP SEL value (10 mg/kg$_{dw}$). The average concentration and individual sample results were all below the maximum site-specific background samples (2 mg/kg$_{dw}$). Given that cadmium concentrations were below the SEL and also below the maximum site-specific background, it is not anticipated that there would be any significant impacts from cadmium to macroinvertebrates in Briar Lake.

- *Iron*: Iron was detected in all six Briar Lake samples with an average concentration of 121,250 mg/kg$_{dw}$ (range: 25,500 to 217,000 mg/kg$_{dw}$). Nearly all of the samples exhibited iron flocculent, so the elevated iron concentrations were not unexpected. The maximum concentration was observed in SED-BL14-02, which was collected near the center of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was greater than that observed in the site-specific background samples (5,640 mg/kg$_{dw}$).

NJDEP has not established LEL or SEL values for iron. The average concentration and all six sample results were greater than the maximum site-specific background sample (14,000 mg/kg$_{dw}$). Three of the six samples were also greater than the maximum concentration for iron from the USGS NURE database (171,000 mg/kg$_{dw}$). The iron flocculent is likely resulting in the elevated iron concentrations in these samples. The flocculent was not removed prior to chemical analysis.

- *Selenium*: Selenium was detected in three of the six Briar Lake samples with an average concentration of 3.6 mg/kg$_{dw}$ (range of detects: 3.7 to 4.7 mg/kg$_{dw}$). The non-detect values ranged from 5 U to 6.6 U mg/kg$_{dw}$ in the remaining samples. The maximum observed concentration was in sample SED-BL14-03, which was collected near the exit culvert of the lake. The minimum observed concentration was in sample SED-BL14-02, which was collected near the center of the lake. The average concentration was greater than the average (and single detection) in the site-specific background samples (1.5 mg/kg$_{dw}$).

  NJDEP has not established LEL or SEL values for selenium. Given that the selenium concentrations were less than the site-specific background, and the observed average was below that from the NURE sediment dataset for New Jersey (average of 0.9 mg/kg$_{dw}$; range of 1 to 4 mg/kg$_{dw}$), it is not anticipated that there would be any significant impacts from selenium to macroinvertebrates.

- *Zinc*: Zinc was detected in all six Briar Lake samples with an average concentration of 413 mg/kg$_{dw}$ (range: 146 to 663 mg/kg$_{dw}$). The maximum concentration was observed in SED-BL14-03, which was collected near the exit culvert of the lake. The minimum concentration was observed in SED-BL14-01, which was collected near the entry culvert from Holly Run. The average concentration was greater than that observed in the site-specific background samples (153 mg/kg$_{dw}$).

  The average concentration was above the NJDEP LEL value (121 mg/kg$_{dw}$) and the average and maximum concentrations were both less than the NJDEP SEL value (820 mg/kg$_{dw}$). These results suggest a potential for impacts to benthic invertebrates if the zinc is in a bioavailable form. This will be evaluated under Measurement Endpoint No. 1-2.

Based on the comparison of the observed results to site-specific background, NJDEP sediment criteria, or in the absence of the latter, the USGS NURE sediment data for New Jersey, it is readily apparent that there are no impacts to benthic invertebrates in either Briar Lake or Holly Run related to the evaluated metals.

COPEC Metal Results in Holly Run Downstream of Briar Lake

The results for the five inorganic COPECs from Holly Run downstream of Briar Lake are summarized below and compared to NJDEP Ecological Screening Criteria (NJDEP 2009) and alternate sediment benchmarks, where appropriate.

- *Arsenic*: Arsenic was detected in both Holly Run samples with an average concentration of 1.65 mg/kg$_{dw}$ (range: 1.6 to 1.7 mg/kg$_{dw}$). The maximum concentration was observed in SED-HR14-04, which was collected within Holly Run just downstream of the discharge from Briar Lake, although both samples had similar concentrations.

  The average arsenic concentration was less than that observed in the site-specific background samples (2.0 mg/kg$_{dw}$). The average and maximum concentrations were both below the NJDEP LEL and SEL values (9.98 and 33 mg/kg$_{dw}$, respectively) for arsenic. Therefore, it is not anticipated that there would be any significant impacts from arsenic to macroinvertebrates in these sediments.

- *Cadmium*: Cadmium was detected in one of the two Holly Run samples (SED-HR14-05; 0.97 mg/kg$_{dw}$). The detection limit in sample SED-HR14-04 was 0.11 mg/kg$_{dw}$. The single detection was below the average concentration (1.1 mg/kg$_{dw}$) from the site-specific background samples.

  The single detection was above the NJDEP LEL value (0.6 mg/kg$_{dw}$) and less than the NJDEP SEL value (10 mg/kg$_{dw}$). Given that cadmium was detected in only one of the sediment samples and at a concentration less than the site-specific background, it is not anticipated that there would be any significant impacts from cadmium to macroinvertebrates.

- *Iron*: Iron was detected in both Holly Run samples with an average concentration of 3,545 mg/kg$_{dw}$ (range: 2,620 to 4,470 mg/kg$_{dw}$). The maximum concentration was observed in SED-HR14-04, which was collected within Holly Run just downstream of the discharge from Briar Lake. There was no evidence of iron staining in either of these samples. The average concentration was less than that observed in the site-specific background samples (5,640 mg/kg$_{dw}$).

  NJDEP has not established LEL or SEL values for iron. Given that the iron concentrations were less than the site-specific background, and the observed average was below that from the NURE sediment dataset for New Jersey, it is not anticipated that there would be any significant impacts from iron to macroinvertebrates in these sediments.

- *Selenium*: Selenium was detected in one of the two Holly Run samples (SED-HR14-05; 1 mg/kg$_{dw}$). The detection limit in sample SED-HR14-04 was 3.7 mg/kg$_{dw}$. The single

detection was below the single detection (1.5 mg/kg$_{dw}$) in the site-specific background samples.

NJDEP has not established LEL or SEL values for selenium. Given that the selenium concentrations were less than the site-specific background, and the observed average was below that from the NURE sediment dataset for New Jersey, it is not anticipated that there would be any significant impacts from selenium to macroinvertebrates in these sediments.

- *Zinc*: Zinc was detected in one of the two Holly Run samples (SED-HR14-04; 10.4 mg/kg$_{dw}$). The detection limit in sample SED-HR14-05 was 6.6 mg/kg$_{dw}$. The single detection was well below the average concentration (151 mg/kg$_{dw}$) in the site-specific background samples.

  The single detection was also below the NJDEP LEL and SEL values (121 and 820 mg/kg$_{dw}$, respectively) for zinc. Therefore, it is not anticipated that there would be any significant impacts from arsenic to macroinvertebrates in these sediments.

In summary, the comparison of the COPEC metal results in the Holly Run sediments downstream of Briar Lake to sediment benchmarks do not suggest any potential impacts to benthic invertebrates.

Measurement Endpoint No. 1-2: Analysis of metal bioavailability to benthic macroinvertebrates

Although metals may be detected in sediments from laboratory testing, they may not exist in forms that are available for contact or uptake by aquatic organisms, therefore rendering them nontoxic. The bioavailability and toxicity of divalent metals in sediments is controlled by formation of insoluble metal sulfides (e.g., Ankley 1996; Christensen 1998). Comparisons of the molar concentration of sulfide anions by weak acid extraction (referred to as acid-volatile sulfide or AVS) and the sum of the molar concentrations of metals released during the same weak acid extraction (referred to as simultaneously extracted metals or SEM)[16] can be used to predict the potential reduction in bioavailability attributable to the formation of insoluble metals sulfides. Iron also plays a role in mediating bioavailability of metals since it plays a role in the sulfide chemistry of soils and sediments (Edwards 1998).

An analysis of the relationship between AVS in sediments and SEM concentrations of the divalent (+2 valence state) metals has been conducted to assess the bioavailability of these metals from the sediments. This evaluation compares SEM/AVS ratios (or differences) as an indicator for bioavailability in addition to TOC which relates bioavailability and toxicity.

[16] The SEM metals were cadmium, copper, lead, mercury, nickel and zinc. Of these, cadmium and zinc were sediment COPECs.

USEPA (2005a) refined the original SEM/AVS ratios (or differences) approach and developed thresholds that relate bioavailability and toxicity to three indicators: AVS, SEM, and TOC. This approach improves the predictability of potential toxicity since it accounts both for the partitioning of metals to sediment organic carbon, as well as the effect of AVS, on the potential toxicity. For this assessment, the difference between SEM and AVS is normalized to the total organic carbon content of the co-collected sediments, and has units of μmol/g_{OC}. Both AVS and SEM are reported by the laboratory using the unit of μmol/g_{sed}, and the TOC content is reported as mg/kg (equivalent to μg_{OC}/g_{sed}). Therefore, the [SEM-AVS]/TOC is calculated using the following equation:

$$[\text{SEM - AVS}]/\text{TOC} = \frac{\text{SEM - AVS}[\mu\text{mol/g}_{\text{sed}}] \times 10^6 [\mu\text{g}_{\text{OC}}/\text{g}_{\text{oc}}]}{\text{TOC}[\mu\text{g}_{\text{OC}}/\text{g}_{\text{sed}}]}$$

The term 10^6 adjusts the units of μg_{OC} to g_{OC}.

Sections 3.4 and 6.1 of the USEPA (2005a) report, identified the following thresholds for the [SEM-AVS]/TOC values:

1. Any sediment with [SEM-AVS]/TOC < 130 μmol/g_{OC} should pose low risk of adverse biological effects due to cadmium, copper, lead, nickel, and zinc.

2. For any sediment with [SEM-AVS]/TOC between 130 and 3,000 μmol/g_{OC}, there may be adverse biological effects due to cadmium, copper, lead, nickel, and zinc.

3. In any sediment with [SEM-AVS]/TOC > 3,000 μmol/g_{OC}, adverse effects due to cadmium, copper, lead, nickel, and zinc may be expected.

4. Any sediment with AVS > 0 would have no adverse biological effects due to silver.

According to the USEPA (2005a) report, these thresholds are similar whether acute or chronic sediment toxicity data are evaluated.

This methodology and the threshold values are well established for the divalent metals. They have also been extended to other metals, such as trivalent chromium (e.g., Rifkin et al., 2004). The behavior of the heavy metals is often controlled by geochemical interactions with iron and manganese (e.g., Smith 1999; Martin 2005). Comparable threshold values, such as the 130 μmol/g_{OC} discussed above, are not readily available for the non-divalent metals.

Table 4-6 shows the calculations and results for [SEM-AVS]/TOC. All of the sediment samples had [SEM-AVS]/TOC values that were well below 130 μmol/g_{OC}, indicating low potential risk of adverse biological effects due to cadmium, copper, lead, nickel, and zinc. The [SEM-AVS]/TOC values were also well below 3,000 μmol/g_{OC}, which is the upper threshold were toxicity is likely.

In summary, none of the 10 samples have [SEM-AVS]/TOC values that would suggest the potential for increased bioavailability or toxicity of cadmium, copper, lead, nickel, and zinc. Zinc was detected in some of the Briar Lake samples greater than the NJDEP SEL benchmark but based on the AVS/SEM results the zinc concentrations are unlikely to be bioavailable and therefore would not pose a potential risk to benthic invertebrates.

4.2.2 Assessment Endpoint No. 2 (Amphibians)

Assessment Endpoint No. 2 assesses the potential effects on amphibians from exposure to the COPEC metals in sediment and surface water. The representative receptor for the amphibians is the green frog (*Rana clamitans melanota*) which was observed during the October 2014 field investigation[17]. Two measurement endpoints have been evaluated for this assessment endpoint.

Measurement Endpoint No. 2-1: Comparison of sediment results to suitable benchmarks

Sediment benchmarks have not been developed to assess risks to amphibians (or reptiles), except for some specific chemicals (e.g., total PCBs). Surrogate species, such as benthic invertebrates, have been used to assess potential risks to amphibians. Therefore, the conclusions from Assessment Endpoint No. 1 would be relevant to amphibians, although likely a more conservative estimate of the potential risks, because benthic invertebrates are considered a highly sensitive ecological receptor. Therefore, it is not anticipated that there are any impacts to amphibians that may inhabit Briar Lake or portions of Holly Run.

Measurement Endpoint No. 2-2: Compare observed filtered surface water concentrations to suitable benchmarks (e.g., surface water quality criteria) to determine potential for adverse effects to amphibians.

The filtered surface water results for the five COPEC metals[18] are compared to the surface water benchmarks in Table 4-7. Figure 4-2 shows the spatial distribution of the COPEC metals in the filtered surface water samples and their corresponding refined benchmarks used to evaluate the results. The key results are summarized below by individual COPEC below.

Filtered Surface Water COPEC Metals

Four of the five COPEC metals were detected in the filtered surface water samples from Holly Run or Briar Lake. Selenium was not detected in any of the filtered samples.

- *Arsenic*: Dissolved arsenic was detected in two of the six Holly Run samples and in one of the four Briar Lake samples. The range of detects were very narrow in Holly Run (2 to 2.2 μg/L) and the concentration was similar in the single detection from Briar Lake

[17] The southern leopard frog (*Rana utricularia*) was also observed during the October 2014 field investigation.
[18] The five sediment COPECs were also assumed to be surface water COPECs for this report.

(2.1 μg/L). The observed detections were all below the NJDEP (2009) chronic criteria for arsenic (150 μg/L). The detection limit for the remaining samples was 10 U μg/L.

- *Cadmium*: Dissolved cadmium was detected in three of the six Holly Run samples and in none of the Briar Lake samples. The detected concentrations in Holly Run ranged from 0.27 to 0.34 μg/L. The maximum detection was in SW-D14-01, which was the field duplicate of SW-BL14-01; the latter had no detectable dissolved cadmium (detection limit of 0.3 U μg/L). The detected concentrations were all below the hardness-corrected acute surface water criteria and two of the locations (SW-HR14-03 and SW-HR14-04) had concentrations that were slightly greater than the sample-specific hardness-corrected NJDEP chronic surface water criteria (HQ values of 1.6 for both samples; Table 4-7). However, the maximum concentrations were below the daphnid EC_{20} value of 0.75 μg/L reported by Suter and Tsao (1996). SW-HR14-03 was collected upgradient of Briar Lake and SW-HR14-04 was collected just downstream of Briar Lake. Both of these locations receive input from an off-property drain line. The detection limits ranged from 0.28 U to 5 U μg/L for the remaining three Holly Run samples and from 0.3 U to 5 U μg/L in the four Briar Lake samples.

- *Iron*: Dissolved iron was detected in all six of the Holly Run samples and in three of the Briar Lake samples. This was not unexpected given the presence of iron biofilm or flocculent at most of the sample locations. The Holly Run detections ranged from 25 to 1,330 μg/L with a mean concentration of 55 μg/L (Table 2-5b). The Holly Run dissolved iron concentrations varied spatially. The lowest relative dissolved iron concentration was in the Holly Run sample collected upstream of the landfill (HR14-06; 25 μg/L). Dissolved iron concentrations increased moving downstream from HR14-01 to HR14-03. Concentrations declined moving downstream from Briar Lake.

  Dissolved iron was also highly variable within Briar Lake, with the detected concentrations ranging from 106 to 763 μg/L, with a mean concentration of 408 μg/L. The higher relative dissolved iron concentrations were collected on the eastern half of the lake. The non-detect result was from the sample collected near the exit culvert (87 U μg/L; BL14-03), which also corresponded to the deeper portion of the lake.

  NJDEP (2009) has not established acute or chronic criteria to assess aquatic organisms. All but one of the samples (SW-HR14-03; HQ = 1.3) had detected dissolved iron concentration that were less than the AWQC chronic criteria (1,000 μg/L; USEPA 2009). The single exceedance is not considered to be ecologically relevant.

- *Zinc*: Dissolved zinc was detected in only one of the six Holly Run samples and in none of the Briar Lake samples. The single detection in Holly Run (70.8 μg/L) was in SW-HR14-06, which was located upgradient of the landfill on GEMS property. The observed concentration was below the hardness-corrected chronic criteria for zinc in this sample

(262 μg/L; Table 4-7). The detection limits ranged from 0.57 U to 10.5 U μg/L for the remaining five Holly Run samples and from 2.3 U to 4.2 U μg/L in the four Briar Lake samples.

In summary, all of the dissolved COPEC concentrations were below NJDEP (2009) chronic surface water criteria or alternate benchmarks, except for an isolated exceedance for dissolved iron. This is not considered to be ecologically significant since the exceedance was isolated to one sample.

4.2.3 Assessment Endpoint No. 3 (Fish)

Assessment Endpoint No. 3 assesses the potential effects on fish from exposure to chemicals in sediment and surface water. Two measurement endpoints have been evaluated for this assessment endpoint.

Measurement Endpoint No. 3-1: Compare filtered constituent concentrations in surface water to New Jersey surface water quality criteria, Federal ambient water quality criteria (AWQC), or other relevant criteria.

This was already performed for Assessment Endpoint No. 2 (Table 4-7), which showed that none of filtered surface water COPEC concentrations were greater than the NJDEP chronic water criteria or other appropriate benchmarks, except for dissolved iron in a single Holly Run sample (SW-HR14-03) collected upstream of Briar Lake. This is unlikely to be significant since fish were more commonly observed in Holly Run downstream of Briar Lake.

Measurement Endpoint No. 3-2: Compare the distribution of filtered constituent concentrations in surface waters with the range of no significant effect concentrations for growth and reproduction for water column fish

Surface water criteria are based on protection of the most sensitive aquatic receptors, which are typically invertebrates. For this measurement endpoint, an additional evaluation of reported no significant effect concentrations for growth and reproduction for water column fish was performed. This evaluation was performed by comparing the observed results to the EC_{20} values for trout reported by Suter and Tsao (1996) and also comparing the results to the geometric mean no effect levels for growth, reproduction or survival effects in fish from the EPA ECOTOX database. Table 4-8 compares the individual filtered surface water results from Briar Lake and Holly Run to benchmarks relevant to fish. The comparison was made to the Briar Lake results even though fish have not been observed in the lake. These results are summarized below by COPEC metal.

Four of the five COPEC metals were detected in the filtered surface water samples from Holly Run or Briar Lake. Selenium was not detected in any of the filtered samples.

- *Arsenic*: Dissolved arsenic was detected in two of the six Holly Run samples and in one of the four Briar Lake samples. The detected concentrations in Holly Run ranged from 2.0 to 2.2 μg/L, and was 2.1 μg/L in Briar Lake. The detected results were well below the EC_{20} value (2,130 μg/L) for trout reported by Suter and Tsao (1996) and the geometric mean no effect value from the ECOTOX database (5,458 μg/L).

- *Cadmium*: Dissolved cadmium was detected in three of the six Holly Run samples and in none of the Briar Lake samples. The detected concentrations in Holly Run ranged from 0.27 to 0.34 μg/L. The detected results were all below the EC_{20} value (1.8 μg/L) for trout reported by Suter and Tsao (1996) and the geometric mean no effect value from the ECOTOX database (11.1 μg/L).

- *Iron*: Dissolved iron was detected in all six of the Holly Run samples and in three of the Briar Lake samples. The detected concentrations in Holly Run ranged from 25 to 1,330 μg/L, and from 106 to 763 μg/L in Briar Lake. Suter and Tsao (1996) did not report an EC_{20} value for trout for iron. There were only two studies that reported NOAEC values for iron in the EPA ECOTOX database. The detected results were all below the geometric mean no effect value from the ECOTOX database (3,832 μg/L).

- *Zinc*: Dissolved zinc was detected in only one of the six Holly Run samples and in none of the Briar Lake samples. The single detection in was from the Holly Run sample collected upstream of the GEMS landfill (SW-HR14-06; 70.8 μg/L). This was slightly greater than the EC_{20} for trout (47 μg /L; HQ = 1.5) reported by Suter and Tsao (1996) but was below the geometric mean no effect value from the ECOTOX database (1,676 μg/L).

In summary, all of the dissolved COPEC concentrations were below the EC_{20} values for fish reported in Suter and Tsao (1996) or the geometric means of the no effect concentrations from the EPA ECOTOX database. Therefore, it is not anticipated that there would be any potential impacts to fish survival, growth or reproduction related to COPEC metals dissolved in the Briar Lake or Holly Run water columns.

4.2.4 Assessment Endpoint No. 4 (Herbivorous Birds)

This assessment endpoint evaluates the potential effects on mid-to-upper trophic level herbivorous bird populations resulting from consumption of forage exposed to chemicals in surface sediment, and/or surface water. One measurement endpoints have been used for this assessment endpoint. The mallard duck has been selected as the representative receptor for this assessment endpoint, since ducks were observed in Briar Lake during the March 2014 site reconnaissance.

Measurement Endpoint 4-1: Compare the back-calculated sediment ingestion benchmarks (SIBs) to observed media concentrations using the average daily doses (ADDs) and TRVs for COPEC metals for this avian receptor.

Table 4-4 shows the derivation of the SIB values for the five COPEC metals for this receptor. All of the SIB values were greater than the maximum possible concentration (i.e., greater than 10^6 mg/kg_{dw}). None of the average or individual sample sediment concentrations were greater than the calculated SIB values (Table 4-9). Therefore, it is not anticipated that there are any ecologically relevant impacts to mallard ducks related to sediment ingestion.

4.2.5 Assessment Endpoint No. 5 (Piscivorous Birds)

This assessment endpoint evaluates the potential effects on mid-to-upper trophic level piscivorous bird populations resulting from incidental consumption chemicals in surface sediment. Three measurement endpoints were used for this assessment endpoint. The Great Blue Heron was selected as the representative receptor for this assessment endpoint.

Measurement Endpoint 5-1: Compare the back-calculated sediment ingestion benchmarks (SIBs) to observed media concentrations using the average daily doses (ADDs) and TRVs for COPEC metals for this avian receptor.

Herons were observed wading in Briar Lake and may also utilize Holly Run downstream of Briar Lake for wading or foraging. Table 4-4 shows the derivation of the SIB values for the five COPEC metals for this receptor. These were compared to the average and ranges of detections in the sediments from Briar Lake and Holly Run (Table 4-10). As shown in this table, none of the average sediment concentrations in Briar Lake or Holly Run were greater than the calculated SIB values. Three of the six individual sample results from Briar Lake slightly exceeded the SIB value (HQ values of 1.1 or 1.2) for iron. None of the individual Holly Run samples were greater than the SIB value. It is not anticipated that there are any ecologically relevant impacts to herons related to sediment ingestion of the COPEC metals since the average sediment concentration is more relevant to the exposure assessment.

4.3 UNCERTAINTY ANALYSIS

There are a number of sources of uncertainty in ecological risk assessments, which can be broadly grouped into three categories - conceptual model uncertainty, natural variation and parameter values uncertainty, and model uncertainty. The following sections discuss these uncertainties, and also include quantitative assessments of these uncertainties wherever possible.

4.3.1 Conceptual Model Uncertainty

The CSM (Figure 3-1) summarizes the potential fate and transport processes and pathways that are ongoing at the site. The CSM also formed the basis for the field investigations, the exposure pathways that have been assessed, the selection of receptors of interest, and the selection of assessment and measurement endpoints. Sufficient field observations and analytical data have been collected to verify that the CSMs area representative of current site conditions. Any future anthropogenic disturbances that can affect the hydrology (including inputs) to the lake may result in changes to the CSMs.

The representative receptors that were included in the CSM were those that have been observed at the evaluated areas during the March 2014 site visit and October 2014 field investigation. As discussed in Section 3.3, the WPTM (Integral 2014a) included an option to assess reptiles, but there was no evidence of use by reptiles (e.g., no sightings of turtles or evidence of turtle activity) at any of the sampled locations. The habitat in Briar Lake and the portions of Holly Run near the GEMS property are not ideal for reptiles, although they may utilize the natural channel portions of Holly Run downstream of Briar Lake. Given that the sediment and surface water samples from these locations did not exceed any of their corresponding benchmarks, it is not anticipated that there would be any impacts from the COPEC metals to reptiles in this downstream area.

4.3.2 Parameter Values

A detailed assessment of the uncertainty in parameter values, as performed as part of ERAGS Step 7, is not relevant at this time since commonly applied benchmarks and default assumptions were used throughout the ERAGS Step 3 assessment. Therefore, the parameter values uncertainty assessment will focus on the following: (1) the representativeness of the COPEC sampling; (2) the assessment of non-COPEC metals; and (3) questions raised by EPA subsequent to the approval of the WPTM. These are discussed below.

4.3.2.1 Representativeness of COPEC Sampling

The sediment sampling program was designed to recollect samples from the locations used in 2006 and also collect additional samples from locations to address data gaps, such as additional samples from Briar Lake and from the natural channel of Holly run downstream of Briar Lake. As was observed in 2006, many of the proposed sample locations in the rip-rap portion of Holly Run on the GEMS property lacked accumulated sediment, so sediments could not be collected from these locations. This should not be interpreted to mean that there is uncertainty in the representativeness of the sediments samples, but rather reflects the proper design and maintenance of the surface drainage system which minimizes the release of soils and sediments from the landfill cap and adjoining areas.

Surface water samples were collected in 2014 (they were not collected in 2006) from the same locations where sediments were proposed. Some adjustments to the sampling locations were made if water was not present or to collect additional information from site features (such as drainage from adjoining properties. Both total and filtered TAL metals were analyzed to allow appropriate characterization of surface water quality.

4.3.2.2 Assessment of Non-COPEC Metals

Section 4.2 focused on the comparisons of the COPEC metal results to refined media benchmarks. An evaluation of the non-COPEC metal results is presented in Appendix D. The key results from these evaluations are summarized below.

- None of the non-COPEC metal sediment results exceeded NJDEP or alternate sediment benchmarks in the reference areas, Holly Run, or Briar Lake.
- None of the non-COPEC metal unfiltered surface water results exceeded NJDEP or alternate surface water benchmarks in Holly Run or Briar Lake.
- None of the non-COPEC metal filtered surface water results exceeded NJDEP or alternate surface water benchmarks in Holly Run or Briar Lake.
- An evaluation of the sediment ingestion of the non-COPEC metal results was not performed because none of the non-COPEC metal results exceeded the sediment benchmarks.

Based on these results, there is little to no uncertainty in focusing the ERAGS Step 3 assessment on the COPEC metals.

4.3.2.3 COPEC Screening of Chlorobenzene

The SLERA prepared by EPA (equivalent to ERAGS Steps 1 and 2) formed the basis of the identification of the COPECs. In Holly Run, the COPECs included four metals, one VOC (acetone) and two SVOCs (acenaphthene and naphthalene). For Briar Lake, the COPECs included nine metals, two VOCs (acetone and chlorobenzene) and one SVOCs [Bis(2-ethylhexyl) phthalate]. A refined COPEC screening was performed in the WPTM (Integral 2014a) which showed that there was no need to further assess the organic chemicals. Subsequent to the approval of the WPTM, EPA requested that an additional evaluation be performed for chlorobenzene.

Chlorobenzene was not detected in the background samples from either the EPA or HydroQual 2006 datasets, but was detected in Holly Run and Briar Lake sediments. The screening value for chlorobenzene in the EPA SLERA was 8.42 μg/kg, which was calculated using the equilibrium partitioning approach using the freshwater value from Region III BTAG Freshwater Screening

Benchmarks (1.3 µg/L)[19] and a TOC of 1%. The Excel file that is used to develop these benchmarks is available on-line[20]. The maximum detected concentration across the EPA split sample dataset was 22.1 µg/kg, and 61 µg/kg in the HydroQual dataset (both in sample BL-03), which would suggest that chlorobenzene should have been retained for further evaluation in ERAGs Step 3.

To assess this further, the Excel file from EPA Region 3 that was used to develop their Freshwater Screening Benchmarks was used to compute site-specific freshwater sediment screening benchmarks using site-specific TOC, the NJ freshwater criterion for chlorobenzene (47 µg/L; NJDEP 2009), and the EPA organic carbon partition coefficient (K_{oc}; calculated value was 648). The updated screening value for chlorobenzene is 1,709 µg/kg based on the average TOC of 5.61%, and ranges from 225 to 7,524 ug/kg when the individual TOC values were used from the HydroQual dataset. None of the observed results were greater than the updated screening values when either the average TOC across the samples or the paired sample and TOC results from the HydroQual dataset were used (Table 4-11). Use of the EPA TOC and chlorobenzene results yielded a similar conclusion (Appendix Table H-2). Therefore, it was appropriate to screen out chlorobenzene prior to the ERAGS Step 3 assessment.

4.3.2.4 Chemicals with Elevated Detection Limits in the EPA SLERA

EPA's Third Five Year Review of the GEMS Landfill (USEPA 2014) identified the need to further assess the reported detection limits for five organics (2,4-dinitrophenol, 4-nitrophenol, hexachlorocyclopentadiene, 2-methylphenol[21] and carbon disulfide) since these were greater than the screening benchmarks that were used in the SLERA. Page 7 of USEPA (2014) states that "*…they are considered unlikely to pose an unacceptable ecological risk; however, the baseline ecological risk assessment will collect additional data to confirm this*." The screening values used in the EPA SLERA were very low for these chemicals and the detection limits that would be needed to meet the conservative screening values used in the SLERA are not realistically achievable using EPA methods for sediments.

The suggestion to further assess these chemicals was based on the results of the split samples collected by EPA during the December 2006 sampling event. Table 4-12 summarizes the reported detection limits and SLERA screening values for these five chemicals. The reported detection limits were re-assessed in the context of the following: (1) standard method detection limits; (2) use of alternate benchmarks; (3) historical presence at the site. These are discussed below:

[19] Available from http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fw/screenbench.htm
[20] This file is available from http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/FW_Sed_TOC_Table_7-06.xls
[21] A common synonym for 2-methylphenol is o-cresol.

Standard Method Detection Limits

The standard detection limits (i.e., based on 100% solids) for these five chemicals in sediments all exceed the SERAS screening values. For example, EPA Method 8270C (USEPA 1996a) lists the following estimated quantitation limits for low soil/sediment: for the four SVOCs of interest

- 2,4-dinitrophenol = 3,300 μg/kg
- 2-methylphenol = 660 μg/kg
- 4-nitrophenol = 3,300 μg/kg
- hexachlorocyclopentadiene = 660 μg/kg

Carbon disulfide is a VOC. The estimated quantitation limits for low soil/sediment following EPA 8260B for carbon disulfide is 5 μg/kg (USEPA 1996b).

Sample specific detection limits can further increase if (1) the samples require dilution to the presence of other targeted chemicals or sample interferences; and (2) with increasing sample moisture contents. Dilution factors were not reported in the SLERA data tables. Sample specific detection limits will increase in sediment samples with increasing moisture content. The moisture contents[22] of the sediments reported in the EPA SLERA are summarized below:

- Background: Range of 27.7 to 85.8% (mean of 60.4%)
- Briar Lake: Range of 25.5 to 43.9% (mean of 36.6%)
- Holly Run: 45.1% (single sample)

There was no specific information provided in the EPA SLERA, such as data validation reports, that described why these chemicals had elevated detection limits. However, it is likely due to a combination of the normal reporting limits for these chemicals and elevated moisture contents of the samples.

Assessment Using Alternate Benchmarks

The SERAS database used in the EPA SLERA includes conservative (i.e., low) benchmarks. To assess the reported detection limits alternative screening benchmarks can be derived using the aforementioned EPA Region 3 Freshwater Screening Benchmarks calculation method using sample-specific TOC values. The alternate benchmarks are discussed below for each of these organic chemicals.

- *Carbon disulfide*: The detection limits reported for this chemical in the EPA SLERA dataset ranged from 8.4 to 56 μg/kg, with the highest detection limit reported in background samples BG-03. The screening value in SERAS is 0.851 μg/kg, which was based on the freshwater sediment criterion from EPA Region 3. NJDEP does not have a surface water quality standard for carbon disulfide. However, Suter and Tsao (1996)

[22] The corresponding percent solids value, which is more commonly reported, is 100% minus these values.

reported an EC_{20} value for fish of 5,719 μg/L (an EC_{20} value for daphnids was not available).

Based on the reported TOC concentrations in the SLERA samples, the re-calculated freshwater sediment screening benchmarks (Appendix Table H-3) using the EPA Region 3 method range from 4,296 to 155,686 μg/kg (mean of 33,208 μg/kg). The reported SLERA detection limits are well below these values. Therefore, although this chemical was greater than the SLERA screening value, none of the detection limits were greater than the updated screening value.

- *2,4-Dinitrophenol* : The detection limits reported for this chemical in the EPA SLERA dataset ranged from 1,000 to 12,000 μg/kg, with the highest detection limit reported in background samples BG-03. The screening value in SERAS is 6.21 μg/kg, which was based on the freshwater sediment ecological screening level from EPA Region 5. The NJDEP (2009) surface water chronic criterion for this chemical is 19 μg/L. This is conservative value given that the 96-hour acute toxicity values for 2,4-dinitrophenol in trout range from 390 to 1,780 μg/L (Holcombe et al 1987, Howe et al 1994).

  Based on the reported TOC concentrations in the SLERA samples (mean of 7.2% and range of 0.93 to 33.7%), the re-calculated freshwater sediment screening benchmarks (Appendix Table H-3) using the EPA Region 3 method range from 7.7 to 281 μg/kg (mean of 60 μg/kg). The reported SLERA detection limits, and standard method detection limits are above these values.

- *2-Methylphenol (o-cresol)*: The detection limits reported for this chemical in the EPA SLERA dataset ranged from 260 to 3,100 μg/kg, with the highest detection limit reported in background samples BG-03. The screening value in SERAS is 12 μg/kg. Suter and Tsao (1996) reported a lowest chronic value (LCV) of 489 μg/L for fish (this was the lowest value across multiple species).

  Based on the reported TOC concentrations in the SLERA samples, the re-calculated freshwater sediment screening benchmarks (Appendix Table H-3) using the EPA Region 3 method range from 376 to 13,617 μg/kg (mean of 2,904 μg/kg). The reported SLERA detection limits are well below these values. Therefore, although this chemical was greater than the SLERA screening value, none of the detection limits were greater than the updated screening values.

- *4-Nitrophenol*: The detection limits reported for this chemical in the EPA SLERA dataset ranged from 1,000 to 12,000 μg/kg, with the highest detection limit reported in background samples BG-03. The screening value in SERAS is 13.3 μg/kg.

  The NJDEP (2009) surface water chronic criterion for this chemical is 60 μg/L but Suter and Tsao (1996) reported an LCV of 481 μg/L for fish (this was the lowest value across

multiple species). Based on the reported TOC concentrations in the SLERA samples, and this LCV value, the re-calculated freshwater sediment screening benchmarks (Appendix Table H-3) using the EPA Region 3 method range from 338 to 12,234 μg/kg (mean of 2,610 μg/kg). All of the reported SLERA detection limits were below these updated screening values.

- *Hexachlorocyclopentadiene*: The detection limits reported for this chemical in the EPA SLERA dataset ranged from 1,000 to 12,000 μg/kg, with the highest detection limit reported in background samples BG-03. The screening value in SERAS is 44 μg/kg, which was based on the freshwater sediment criterion from New York State (NYSDEC 1999)[23]. This value was derived from the chronic benthic toxicity value of 4.4 μg /gOC and assumed a TOC of 1%.

  Based on the reported TOC concentrations in the SLERA samples and the current NJDEP (2009) chronic surface water criteria for this chemical, the re-calculated freshwater sediment screening benchmarks (Appendix Table H-3) using the EPA Region 3 method range from 64,500 μg/kg to 2,300,000 μg/kg (mean of 500,000 μg/kg). The reported SLERA detection limits are well below these values. Therefore, although this chemical was greater than the SLERA screening value, none of the detection limits were greater than the updated screening values.

Historical Presence at the Site

There is no known history of use of these five chemicals at the site. None of these five chemicals have been reported in any of the historical sampled media at the landfill.

Synopsis: Five chemicals had detection limits greater than their corresponding screening values in the EPA SLERA. Based on the preceding evaluation, it is unlikely that any of the potential ecological risks would be underestimated by excluding these five chemicals from the ERAGS Step 3 risk evaluation for the following reasons: (1) the standard method detection limits were used and adjusted for sample-specific conditions, such as moisture content, which is consistent with standard EPA protocols; (2) the elevated detection limits were below alternate screening benchmarks and/or benchmarks adjusted for site-specific sediment TOC results; and (3) none of these five chemicals have been reported in any of the historical sampled media at the landfill.

4.3.2.5 Screening of Chemicals with Multiple Results - Naphthalene

Following the approval of the WPTM (Integral 2014a), EPA requested[24] that an additional evaluation be performed for naphthalene in sediments. Naphthalene was screened out as a COPEC in the WPTM because it was detected at similar concentrations in the background

[23] New York has recently updated their sediment screening values (NYSDEC 2014).
[24] This was a requested as part of an email correspondence between Nica Klaber of EPA and Bill Lee of *dmi* on 26 September 2014.

samples (10 to 48 µg/kg) compared to the Briar Lake samples (16 to 52 µg/kg) in the HydroQual dataset. EPA did not report any detectable naphthalene in their conventional SVOC analysis (detection limits ranged from 100 to 1,200 µg/kg), but did detect this chemical in some of the samples using the PAH-SIMS method. The PAH-SIMS results (in µg/kg) are summarized in the table below.

BG-01	BG-03	BL-01	BL-02	BL-03	HR-04
52.4	120 U	11 U	54.1	36.4	234

The single Holly Run sample (HR-04), which was located downstream of Briar Lake, had the highest detected concentration for naphthalene in the EPA dataset. There was no specific information provided in the EPA SLERA, such as data validation reports that discuss why the PAH-SIMS results had detectable naphthalene in this sample while the conventional analysis had no detectable naphthalene, despite the latter having a reporting limit (100 µg/kg) that was below the maximum detected amount in the PAH-SIMS analysis. PAH-SIMS analyses have lower detection limits than conventional PAH analysis (typically at least by an order of magnitude) and are less impacted by interferences, so there may have been an issue with quantifying naphthalene in the conventional SVOC analysis of this sample.

The concentration in Holly Run sediment sample HR-04 was greater than the current NJDEP Ecological Screening Criteria (176 µg/kg; NJDEP 2009). This value was based USEPA Region 5 RCRA Ecological Screening Levels (ESLs)[25], which in turn was based on the Consensus-based Threshold Effect Concentration (TEC)[26] from MacDonald et al. (2000). The TEC for naphthalene was the geometric mean of the following values:

- Minimal Effect Threshold of 400 µg/kg, (EC and MENVIQ 1992)
- Effect Range Low (ER-L) of 340 µg/kg, (Long and Morgan 1991)
- Threshold Effect Level for *Hyalella* (28 day test) of 15 µg/kg (USEPA 1996c)
- Sediment Quality Advisory Level (SQAL) of 470 µg/kg (USEPA 1997c)

Three of these no or minimal effect levels are between 340 and 470 µg/kg, and the observed PAH-SIMS value in HR-04 (234 µg/kg) was below these three values. The TEC, because it is a geometric mean, is greatly affected by the very low value of 15 µg/kg reported as the *Hyalella* threshold effect level, which yielded the very conservative value of 176 µg/kg used by NJDEP (2007). Furthermore, these values all assume a TOC content of 1%. Given that the TOC content of HR-04 is 2.34%, the adjusted NJDEP screening value is 412 µg/kg, which is greater than the observed naphthalene result in sample HR-04. Therefore, it is unlikely that the reported concentration for naphthalene from the SIMS analysis of the sample from HR-4 represents a potential risk to aquatic receptors.

[25] http://epa.gov/region5/waste/cars/pdfs/ecological-screening-levels-200308.pdf
[26] The TEC is the concentration below which harmful effects are unlikely.

5 SCIENTIFIC/MANAGEMENT DECISION POINT SYNOPSIS

Generally, SMDPs provide an opportunity to fine tune and focus any additional activities needed to address the specific goals of the different steps in the ERAGS process (USEPA, 1997). SMDPs also provide the opportunity to exit the process where the weight of evidence supports no further action.

5.1 EPA JUNE 2013 CORRESPONDENCE QUESTIONS

The EPA correspondence dated June 20, 2013 to the GEMS trust requested that the BERA should include a discussion that centers on the following four questions:

1. Provide EPA with current/additional monitoring data;
2. Help EPA learn more about the potential ecological risk at Briar Lake and Holly Run;
3. Help EPA better understand the meaning of sampling data collected; and
4. Provide information to assist EPA in determining whether or not there is still a potential ecological risk at Briar Lake and Holly Run.

Because these questions are integral to the development of the SMDP for ERAGS Step 3, the relevant information to address each of these questions is summarized below.

Provide EPA with Current/Additional Monitoring Data

The database prepared for this project (and provided on the CD with this report) contains both the 2006 and 2014 field sampling results. Data related to monitoring of the treated landfill discharge to the CCMUA are provided electronically to EPA on a monthly basis. Groundwater data is also provided electronically to EPA.

Help EPA Learn More About the Potential Ecological Risk at Briar Lake and Holly Run

The WPTM (Integral 2014a) field program was developed as a combination of a verification assessment of the 2006 sample results and address data gaps. The work elements to address the latter included (1) the collection of surface water samples (not performed in 2006); (2) collection of additional sediment locations to better define COPEC concentrations in Briar Lake and the natural channel of Holly Run downstream of Briar Lake; (3) perform an assessment of the potential bioavailability of divalent metals ions, two of which were sediment COPECs (cadmium and zinc); and (4) performance of a qualitative ecological assessment to determine habits present at the sampled areas.

Help EPA Better Understand the Meaning of Sampling Data Collected; and Provide Information to Assist EPA in Determining Whether or Not There is Still a Potential Ecological Risk at Briar Lake and Holly Run

The key findings related to the COPEC metals are the following:

- The WPTM (Integral 2014a) included a summary of the 2006 sediment results reported by HydroQual (2007) and the split samples from EPA that were used to prepare their SLERA. The October 2014 verification samples had similar concentrations to those collected in December 2006.

- Surface Water Results: Low levels of COPEC metals were detected in filtered surface water samples from Briar Lake and Holly Run (surface water was not available from the background locations). These results were all below NJDEP surface water quality criteria (NJDEP 2009), EPA AWQC values (EPA 2009) or other benchmarks (e.g., Suter and Tsao 1996) with exception of iron in one Holly Run sample. This is not considered to be ecologically significant since the exceedance was isolated to one sample and there is limited habitat available for aquatic receptors at this location.

- Background Sediments: Sediments from the Background locations were below sediment benchmarks or regional USGS background concentrations.

- Holly Run Sediments: Sediments were present only in the natural channel portion of Holly Run downstream of Briar Lake. Sediments in Holly Run were below sediment benchmarks or background concentrations.

- Briar Lake Sediments: There were exceedances of sediment benchmarks for some of the COPEC metals in Briar Lake. These are discussed below:

    - *Arsenic*: Arsenic was greater than the sediment LEL benchmark, site-specific background, and regional background for nearly all of the sediment samples, and three sample locations were approximately twice the sediment SEL, implying a potential for benthic toxicity at these locations. However, it is unclear whether arsenic was site-related. Although arsenic has been detected in the piezometers that are installed along Holly Run, all but one of these have low levels of arsenic (approximately 3 µg/L on average). The single exception is PM-19 (average of 112 µg/L; range from 66.8 to 230 µg/L) which is located near the entry road of the landfill and several thousand feet from Briar Lake. Arsenic was detected in the 2002 treatment plant influent samples (average of 10 µg/L; range from 5.7 to 14.2 µg/L). Pre-remediation groundwater or surface water data for arsenic were not available for review. The 2014 surface water concentrations were also comparable to those reported in most of the piezometer samples (2 to 4 µg/L for total or filtered samples).

- *Cadmium*: Cadmium was greater than the sediment LEL benchmark at three of the six Briar Lake locations but all were below the SEL benchmark and below the maximum site background. The cadmium LEL exceedances are not considered ecological significant because the AVS/SEM/TOC analysis showed that all of the divalent metals (including cadmium) are not bioavailable and unlikely to cause any toxicity

- *Iron*: There are no sediment benchmarks available for iron, so the observed concentrations were compared to the site background samples and regional background. All of the Briar Lake samples were greater than the maximum site background samples and three were also greater than the regional background data. Iron flocculent is present throughout Briar Lake which likely skewed the iron results. Although above background concentrations there does not appear to be any ecological effects related to the iron flocculent.

- *Selenium*: Selenium was detected in three of the six samples from Briar Lake. There are no sediment benchmarks available for selenium, so the observed concentrations were compared to the site background samples and regional background. All of the detected Briar Lake samples were greater than the maximum site background samples and two were slightly greater than the regional background data.

- *Zinc*: Zinc was greater than the sediment LEL benchmark but all locations were below the SEL benchmark and one of the samples was greater than the site background samples. The zinc LEL exceedances are not considered ecological significant because the AVS/SEM/TOC analysis showed that all of the divalent metals (including zinc) are not bioavailable and unlikely to cause any toxicity.

- None of the COPEC metal concentrations in the Briar Lake sediments represented a potential hazard from ingestion for herons (except for iron) or ducks. Despite the exceedances of sediment criteria, Briar Lake is being utilized by aquatic organisms (amphibians) and semi-aquatic organisms (herons and ducks).

- The rip-rap portions of Holly Run on the GEMS property does not provide suitable habitat for ecological receptors, such as benthic invertebrates, chiefly due to the absence of contiguous sediments. The natural channel of Holly Run downstream of Briar Lake has sufficient sediment and stable hydrology to maintain aquatic receptors. The RBA score was much higher for the natural channel portions for Holly Run relative to the on-property portions.

- Briar Lake appears to be filling with sediments since the Phase I remedial action was implemented. There is a layer of iron flocculent that overlies the sediment bed in the

lake, but this is not present downstream of the lake. These results suggest that the elevations of the inlet and exit culverts are properly positioned to minimize release of sediments from the lake.

5.2 SMDP RECOMMENDATIONS

Based upon the assessment performed as part of ERAGS Step 3, the following SMDPs are recommended:

- There are no apparent ecological impacts related to sediment or surface COPEC metal concentrations in the background areas or within Holly Run. Therefore, no further evaluation of these areas is warranted.

- There were exceedances of sediment benchmarks for arsenic, iron and zinc in Briar Lake. Of these, only arsenic may be of potential concern for toxicity at some of the locations. However, it is unclear whether the arsenic in Briar Lake sediments is site-related (based upon review of the available groundwater and Holly Run underdrain data) or from other sources. Furthermore, given that the Briar Lake has extensive algal growth, and is being utilized by aquatic organisms (amphibians) and semi-aquatic organisms (herons and ducks), it is unlikely that COPEC metals results pose significant ecological risk.

- Briar Lake is properly operating as a retention pond for the GEMS property and adjoining areas. Sediments have been accumulating particularly on the east side near the Holly Run inlet, and have significantly reduced the depth of the lake in this area (water column depth of a few inches), relative to the original Phase I remediation plans (water column depth of 2-ft). It is not clear whether this sediment accumulation is derived exclusively from runoff from the GEMS property, given that there is no extensive sediment accumulation within the rip-rap channel of Holly Run adjoining the capped landfill, and the GEMS property is landscaped (i.e., low potential for suspended solids runoff, except perhaps from dirt roadways). The sediments within the lake are also covered with a layer of iron flocculent. Although there are no ecological impacts apparent from the iron flocculent in Briar Lake, this material affects the aesthetic value of the lake.

Based on the ERAGS Step 3 assessment, further ecological evaluation of Holly Run or Briar Lake is not required and the ERAGS process can be exited at this stage.

6 REFERENCES

Ankley, G.T. 1996. Evaluation of metal/acid-volatile sulfide relationships in the prediction of metal bioaccumulation by benthic macroinvertebrates. Environ. Toxicol. Chem. 15: 2138–2146.

Baes III, C.F., R.D. Sharp, A.J. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Oak Ridge National Laboratory. ORNL-5786. September. Available from http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/documents/ornl5786.pdf

Beyer, W.N., E.E. Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildlife Manage. 58:375-382.

Christensen, E.R. 1998. Metals, acid-volatile sulfides, organics, and particle distributions of contaminated sediments. Wat. Sci. Tech. 37(6-7): 149-156.

dmi and Cornerstone Environmental Group. 2014. Deep Horizontal Groundwater Extraction Well and Off-Site Groundwater Investigation Work Plan, GEMS Landfill. 16 September.

EC and MENVIQ (Environment Canada and Ministere de l'Envionnement du Quebec) (1992) Interim criteria for quality assessment of St. Lawrence River sediment. Environment Canada, Ottawa.

Edwards, P.J. 1998. Sulfur Cycling, Retention, and Mobility in Soils: A Review. Department of Agriculture, Forest Service, Northeastern Research Station. General Technical Report NE-250. 17p. Available from http://www.treesearch.fs.fed.us/pubs/3808.

Fritioff, A. and M. Greger. 2006. Uptake and distribution of Zn, Cu, Cd, and Pb in an aquatic plant *Potamogeton natans*. Chemosphere. 63(2): 220-227.

Holcombe, G.W., G.L. Phipps, A.H. Sulaiman, and A.D. Hoffman. 1987. Simultaneous multiple species testing: acute toxicity of 13 chemicals to 12 diverse freshwater amphibian, fish, and invertebrate families. Archives of Environmental Contamination and Toxicology 16:697-710.

Howe, G.E., L.L Marking, T.D. Bills, J.J Rach and F.L. Mayer Jr. 1994. Effects of water temperature and pH on toxicity of terbufos, trichlorfon, 4-nitrophenol and 2,4-dinitrophenol to the amphipod *Gammarus pseudolimnaeus* and rainbow trout (*Oncorhynchus myk*iss). Environmental Toxicology and Chemistry. 13(1):51-66

HydroQual. 2006. Holly Run and Briar Lake Sediment Sampling Work Plan, GEMS Landfill Site. 18 May.

HydroQual. 2007. Holly Run and Briar Lake Sediment Sampling Investigation Report, GEMS Landfill Site. 8 February.

Integral Consulting Inc (Integral). 2014a. Work Plan Technical Memorandum, Step 3 Ecological Risk Assessment of Holly Run and Briar Lake Near the GEMS Landfill, Gloucester Township, New Jersey. Prepared for *de maximis, inc*. Final. 12 August.

Integral Consulting Inc. (Integral). 2014b. Quality Assurance Project Plan, Step 3 Ecological Risk Assessment of Holly Run and Briar Lake Near the GEMS Landfill, Gloucester Township, New Jersey. Prepared for *de maximis, inc*. Draft. 10 September.

Kushlan, J. A. 1978. *Feeding ecology of wading birds. In: Sprunt, A.; Ogden, J.; Winckler, S., eds. Wading Birds*. Natl. Audubon Soc. Res. Rep. 7; pp. 249-296.

Long E.R. and L.G. Morgan. 1991. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration, Seattle, WA, 175 pp 1 appendices. Available from http://docs.lib.noaa.gov/noaa_documents/NOS/OMA/TM_NOS_OMA/nos_oma_52.pdf

Lopes, T.J. and S.G. Dionne. 1998. A Review of Semivolatile and Volatile Organic Compounds in Highway Runoff and Urban Stormwater. USGS, Open-File Report 98-409. 67 p. Available from http://sd.water.usgs.gov/nawqa/pubs/ofr/ofr98-409.pdf..

MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Arch. Environ. Contam. Toxicol. 39: 20-31.

Martin, S.T. 2005. Precipitation and Dissolution of Iron and Manganese Oxides. Chapter 3 in V.H. Grassian (editor), Environmental Catalysis. CRC Press, Boca Raton, FL. Available from http://www.seas.harvard.edu/environmental-chemistry/publications/Martin_Env_Catalysis_Chapter.pd

McGhee, F., C.R. Greger, and J.R. Couch. 1965. Copper and iron toxicity. Poultry Science. 44: 310. [As cited in NAS (1980)]

Nagy, KA. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecolog. Monographs. 57(2): 111-128.

National Academy of Sciences (NAS). 1980. Mineral Tolerance of Domestic Animals. National Academies of Science, Board on Agriculture. Available at: http://www.nap.edu/openbook.php?isbn=0309030226

NJDEP. 2013. Site Remediation Program Electronic Data Interchange Manual. Updated 21 February 2013. Available from http://www.state.nj.us/dep/srp/hazsite/docs/edi/edimanual_2013_02.pdf.

NJDEP. 2009. Ecological Screening Criteria Table. Site Remediation Program, Environmental Toxicology and Risk Assessment Unit. 10 March. Available from http://www.nj.gov/dep/srp/guidance/ecoscreening/esc_table.xls.

NYSDEC. 1999. Technical Guidance for Screening Contaminated Sediments. Division of Fish, Wildlife and Marine Resources. 25 January.

NYSDEC. 2014. Screening and Assessment of Contaminated Sediment. Division of Fish, Wildlife and Marine Resources. Bureau of Habitat. 24 June. Available from http://www.dec.ny.gov/docs/fish_marine_pdf/screenasssedfin.pdf.

Rifkin, E., P. Gwinn and E. Bouwer. 2004. Peer Reviewed: Chromium and Sediment Toxicity. Environ. Sci. Technol. 38(14): 267A–271A.

Sanders, P.F. 2003. Ambient Levels of Metals in New Jersey Soils. Research Project Summary. May. Available from http://www.state.nj.us/dep/dsr/research/ambient-levels-metal.pdf

Signal Corporation. 2004. Screening Ecological Risk Assessment System (SERAS). Software developed for the U.S. EPA Environmental Response Team, Edison, NJ. Available from http://www.ertsupport.org/seras_home.htm.

Smith, K.S., 1999, Metal sorption on mineral surfaces: an overview with examples relating to mineral deposits, Chapter 7, in Plumlee, G.S., and Logsdon, M.J., eds., *The Environmental Geochemistry of Mineral Deposits, Part A: Processes, Techniques, and Health Issues*, Reviews in Economic Geology, Vol. 6A: Littleton, Colorado, Society of Economic Geologists, Inc., p. 161-182. Available from http://www.clu-in.org/conf/tio/r10hardrock3_030513/Ch7Smith_SEG1999.pdf.

Smith, S.M. 2006. National Geochemical Database—reformatted data from the National Uranium Resource Evaluation (NURE) Hydrogeochemical and Stream Sediment Reconnaissance (HSSR) Program. USGS. OFR 97-492. Version 1.4. Available from: http://mrdata.usgs.gov/nure/sediment/

Suter II, G.W. and C.L Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. ES/ER/TM-96/R2. June. Available from http://rais.ornl.gov/documents/tm96r2.pdf.

USEPA. 1993. Wildlife Exposure Factors Handbook. EPA/600/R-93/187. Available from: http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=489605. U.S. Environmental Protection Agency, Office Research and Development. December.

USEPA. 1996a. Method 8270C: Semivolatile Organic Compounds By Gas Chromatography/Mass Spectrometry (GC/MS). December. Revision 3. Available from http://www.caslab.com/EPA-Methods/PDF/8270c.pdf

USEPA. 1996b. Method 8260B: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). December. Revision 2. Available from http://www.epa.gov/wastes/hazard/testmethods/sw846/pdfs/8260b.pdf

USEPA. 1996c. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. EPA 905-R96-008, Great Lakes National Program Office, Region V, Chicago, IL

USEPA. 1997a. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. Interim Final. EPA 540/R-97/006. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC. June.

USEPA. 1997b. Superfund Program Representative Sampling Guidance, Volume 3: Biological. Interim Final, May. Available from http://www.epa.gov/oswer/riskassessment/ecorisk/pdf/appb.pdf

USEPA. 1997c. The Incidence and Severity of Sediment Contamination in Surface Waters of the United States. Volume 1: National Sediment Quality Survey. EPA 823-R-97-006, Office of Science and Technology, Washington, DC

USEPA. 1998. Lake and Reservoir Bioassessment and Biocriteria Technical Guidance Document. August. Office of Water. EPA-841-B-98-007. Available from http://water.epa.gov/type/lakes/assessmonitor/bioassessment/upload/lake-and-reservoir-bioassessment-and-biocriteria.pdf.

USEPA. 1999a. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. Second Edition. Office of Water. EPA-841-B-99-002. Available from http://water.epa.gov/scitech/monitoring/rsl/bioassessment/

USEPA. 1999b. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Appendix C: Media-To-Receptor Bioconcentration Factors (BCFs). EPA530-D-99-001A. Office of Solid Waste and Emergency Response. August.

USEPA. 2003. Ecological Soil Screening Level for Iron. Interim Final. OSWER Directive 9285.7-69. November. Available from http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_iron.pdf

USEPA. 2005a. Ecological Soil Screening Levels for Arsenic. Interim Final. OSWER Directive 9285.7-62. March. Available from http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_arsenic.pdf

USEPA. 2005b. Ecological Soil Screening Levels for Cadmium. Interim Final. OSWER Directive 9285.7-65. March. Available from http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_cadmium.pdf

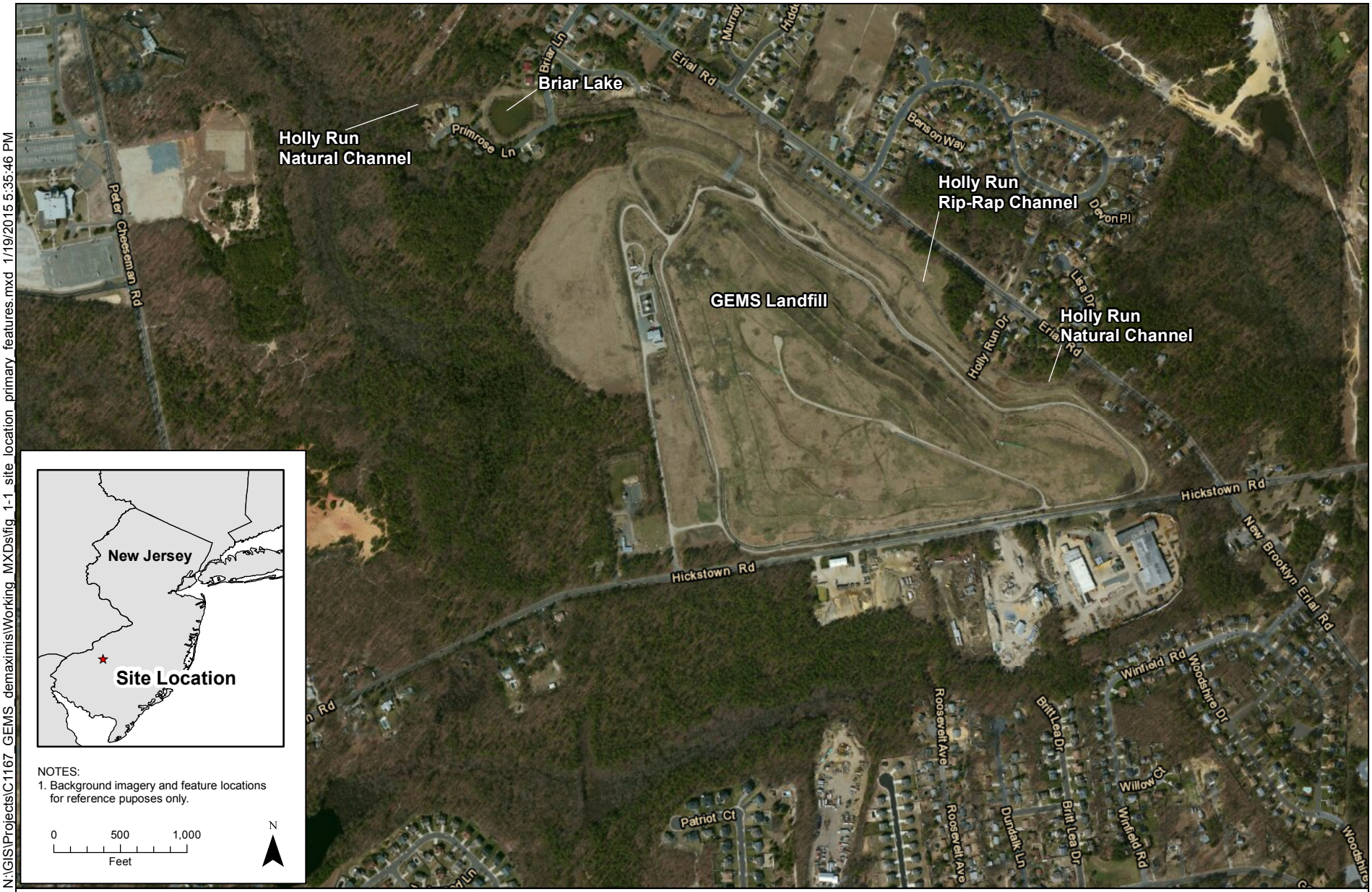
USEPA. 2007a. Ecological Soil Screening Levels for Selenium. Interim Final. OSWER Directive 9285.7-72. July. Available from http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_selenium.pdf

USEPA. 2007b. Ecological Soil Screening Levels for Zinc. Interim Final. OSWER Directive 9285.7-73. June. Available from http://www.epa.gov/ecotox/ecossl/pdf/eco-ssl_zinc.pdf

USEPA. 2009. National Recommended Water Quality Criteria. Office of Water, Office of Science and Technology. Available from http://water.epa.gov/scitech/swguidance/standards/criteria/current/upload/nrwqc-2009.pdf

USEPA. 2014. Third Five-Year Report, GEMS Landfill Superfund Site, Gloucester Township, Camden County, New Jersey. 3 April. Available from http://www.epa.gov/superfund/sites/fiveyear/f2014020004677.pdf

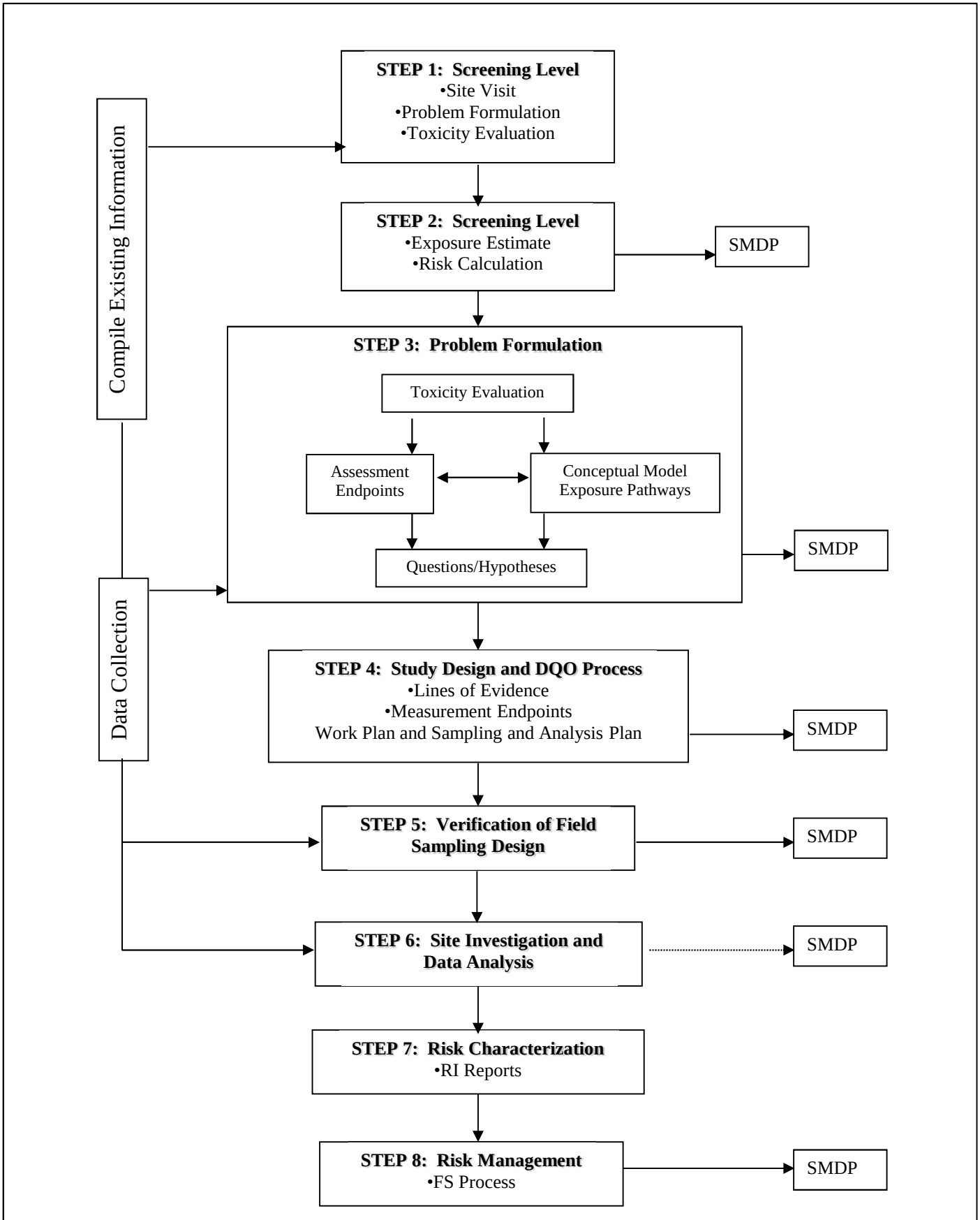
FIGURES



N:\GIS\Projects\C1167_GEMS_demaximis\Working_MXDs\fig_1-1_site_location_primary_features.mxd 1/19/2015 5:35:46 PM

integral consulting inc.

Figure 1-1
Site Location and Primary Features
GEMS Landfill, Gloucester Township, Camden County, New Jersey



integral consulting inc.

Figure 1-2.
Ecological Risk Assessment Process
Flow Diagram

N:\GIS\Projects\C1167_GEMS_demaximis\Working_MXDs\Fig_2-1_sampling_locations_v2.mxd 1/19/2015 5:10:38 PM

Background imagery is for reference purposes only, and is courtesy of ESRI.

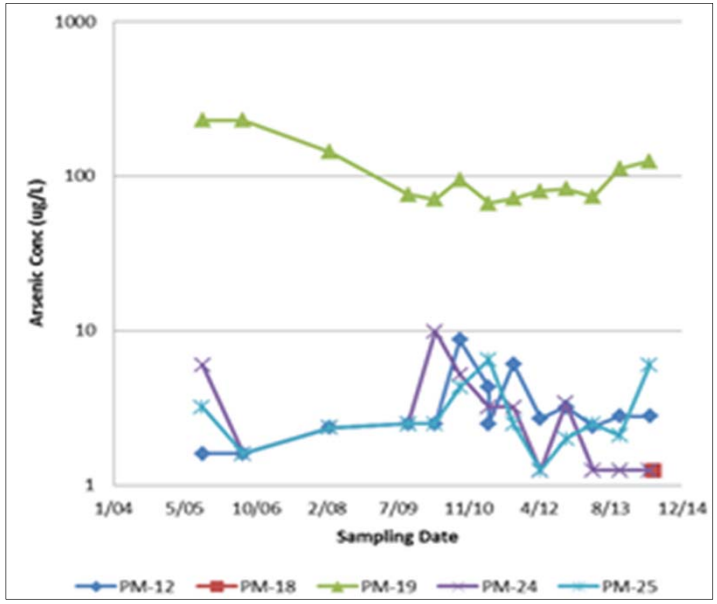
integral consulting inc.

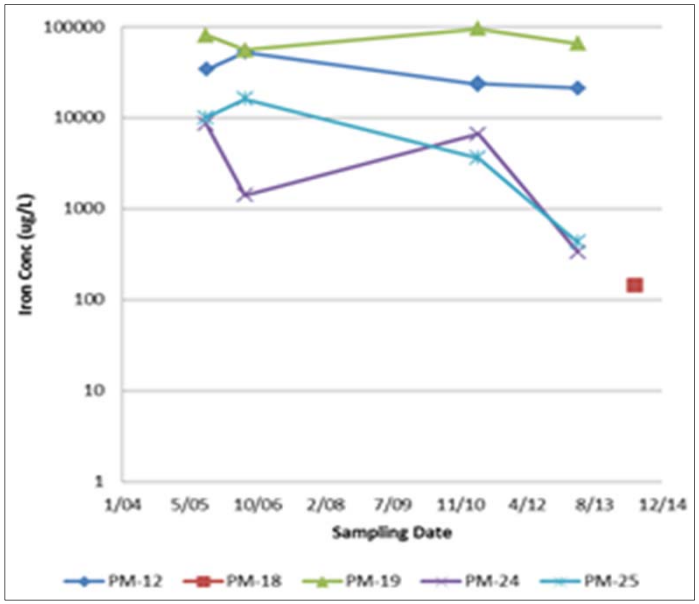
Figure 2-1.
Surface Water and Sediment Sampling Locations from the October 2014 Field Investigation. GEMS Landfill, Gloucester Township, Camden County, New Jersey

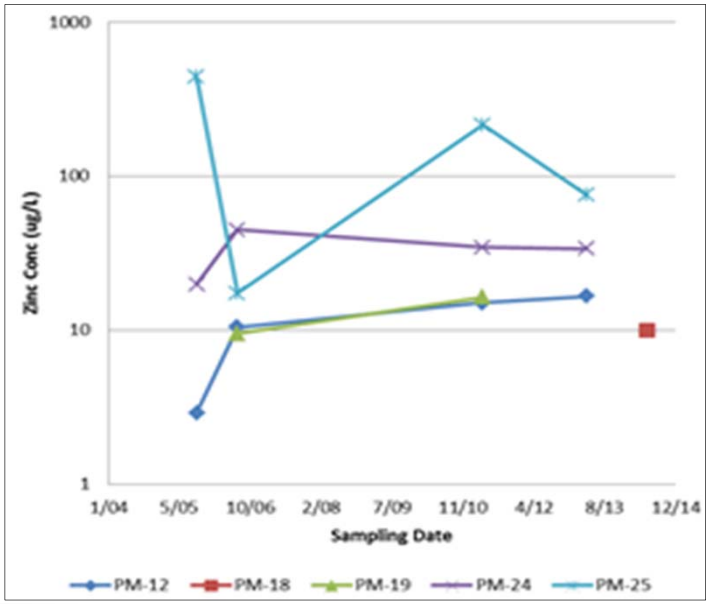
Note:
The COPEC metal results from five shallow piezometers (PM-12, PM-18, PM-19, PM-24, and PM-25) located near Holly Run are evaluated in this report.

integral consulting inc.

Figure 2-2.
Piezometer locations relative to surface water sampling locations near the GEMS Landfill.



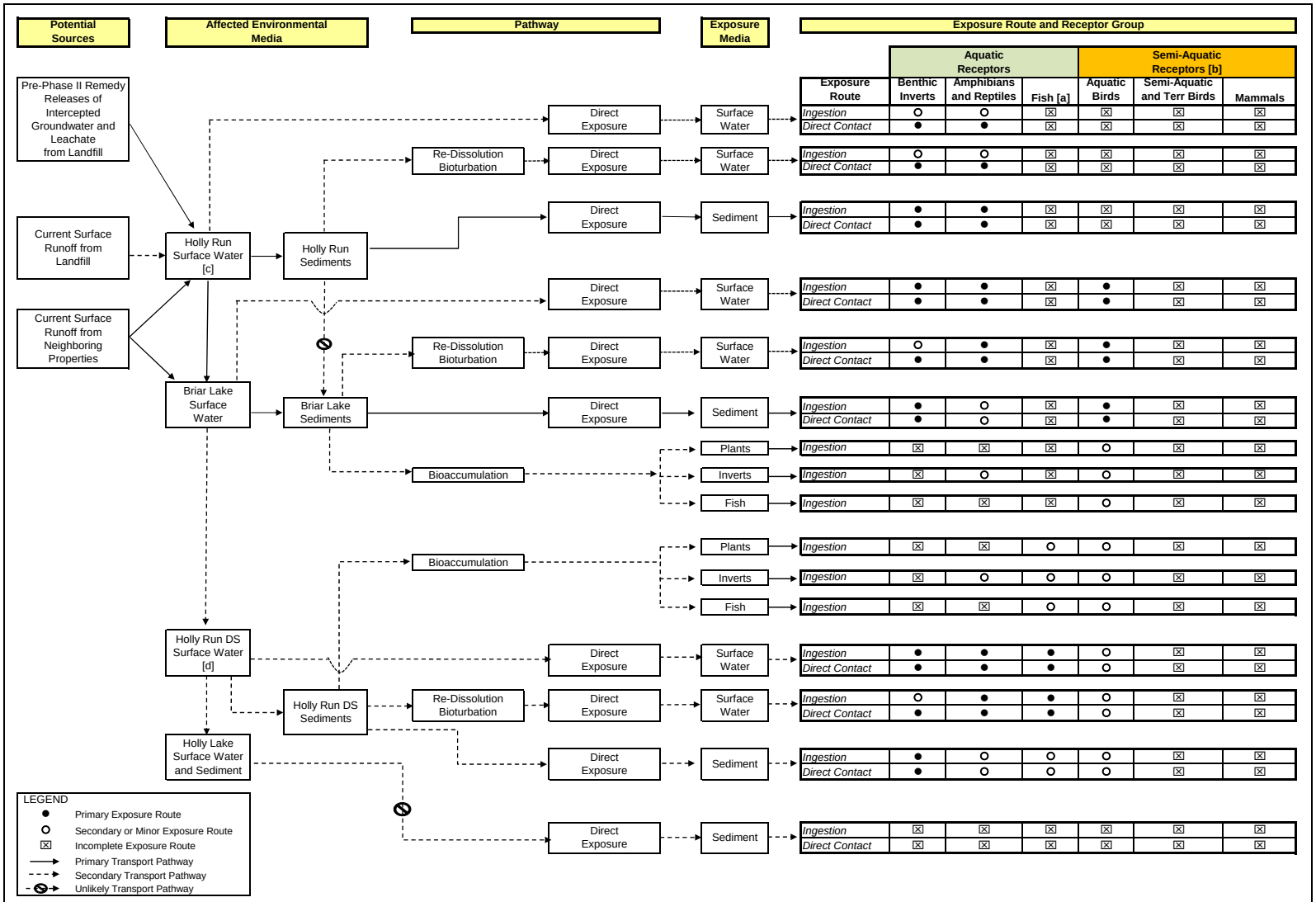




Notes:
Non-detects plotted as one-half the reporting limits.
Concentrations are plotted on log scales.
The remaining COPEC metals (cadmium and selenium) were not detected in any of the piezometer samples.

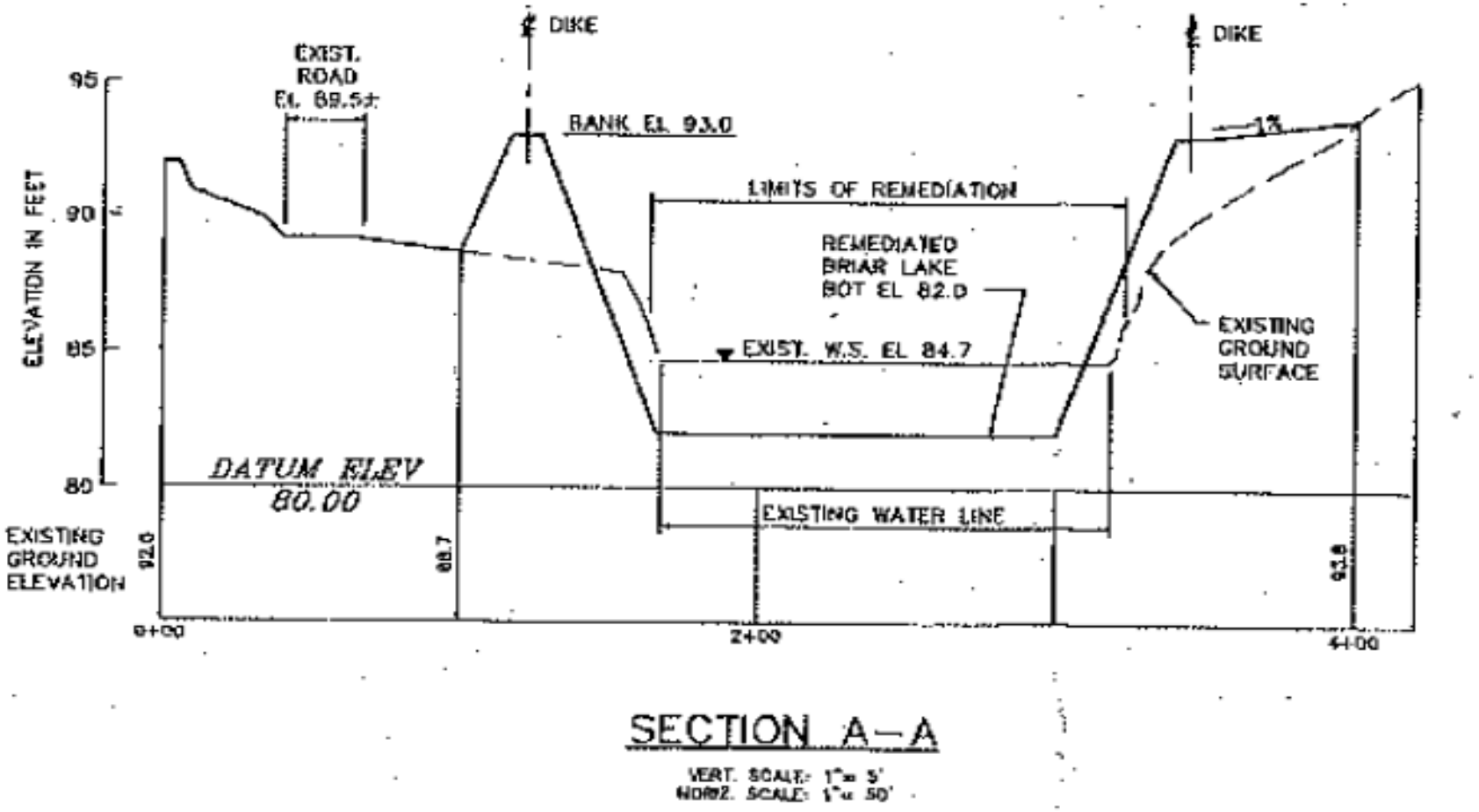
integral consulting inc.

Figure 2-3.
Temporal variation of COPEC concentrations in piezometers near Holly Run.



Notes:
The chemicals of interest for the CSM are the following: Arsenic, cadmium, iron, selenium and zinc.
A dashed line indicates that this is likely a de minimis transport or exposure pathway under current conditions. Surface water may be minor direct exposure source based on measured chemical concentrations.
Briar Lake is likely used seasonally by amphibians for breeding but is too small to support waterfowl, except for transient use (e.g., resting). During the October 2014 field investigation a Great Blue Heron was observed wading in the lake.
This is an update to the preliminary CSM provided in the Work Plan Technical Memorandum (Integral 2014a) based on observations made during the October 2014 field investigation.
[a] Fish were not observed in Briar Lake during neither the March 2014 site visit nor the October 2014 feld investigation. Fish were observed in Holly Run downstream of Briar Lake.
[b] Examples of typical species are the following: aquatic birds - mallard ducks (herbivores); semi-aquatic birds - herons (piscivores); mammals - muskrat (herbivores), and raccoon (omnivores).
[c] Refers to the surface water in Holly Run that is upstream of Briar Lake. Small amounts were present in Holly Run downgradient of the GEMS landfill (but not along the landfill toe) during the October 2014 field investigation.
[d] "Holly Run DS" refers to the portions of Holly Run downstream of Briar Lake.

Figure 3-1.
Revised Conceptual Site Model for Holly Run and Briar Lake
GEMS Landfill - Gloucester Township, New Jersey



Notes:
1. The difference between the existing water level and sediment bottom is 2.7-ft.
2. Excerpt of TAMS "Holly Run and Briar Lake Remediation Plan, Profile and Sections", Drawing No. 111.
3. This cross-section is near the exit culvert. Entry culvert cross-section had same bottom elevation of 82 ft.
4. As-Built drawings for Briar Lake Phase I remediation were not available.

integral consulting inc.

Figure 3-2.
Construction Design Drawing for Phase I Remediation Plan of Briar Lake

SED-HR14-05		
Parameter	Result	Benchmark
Arsenic	1.6 J	9.98, 33
Cadmium	0.97	2
Iron	2,620	14,000
Selenium	1 J	1.5
Zinc	6.6 U	447
$Diff_{SEM-AVS}$/TOC	-287.4	

SED-BG14-04		
Parameter	Result	Benchmark
Arsenic	1.7 UJ	9.98, 33
Cadmium	2	0.6, 10
Iron	1,070 J	---
Selenium	5.5 UJ	---
Zinc	3.9 U	121, 820
$Diff_{SEM-AVS}$/TOC	-10.9	

SED-BG14-05		
Parameter	Result	Benchmark
Arsenic	3.2 J	9.98, 33
Cadmium	0.34 J	0.6, 10
Iron	14,000 J	---
Selenium	3.2 UJ	---
Zinc	447 J	121, 820
$Diff_{SEM-AVS}$/TOC	-185.9	

SED-HR14-04		
Parameter	Result	Benchmark
Arsenic	1.7 J	9.98, 33
Cadmium	0.11 U	2
Iron	4,470	14,000
Selenium	3.7 U	1.5
Zinc	10.4	447
$Diff_{SEM-AVS}$/TOC	-49.6	

SED-BL14-04		
Parameter	Result	Benchmark
Arsenic	66.8 J	9.98, 33
Cadmium	1.3 J	2
Iron	191,000 J	14,000
Selenium	4.3 J	1.5
Zinc	635 J	447
$Diff_{SEM-AVS}$/TOC	-102.0	

SED-BL14-03		
Parameter	Result	Benchmark
Arsenic	65.9 J	9.98, 33
Cadmium	1.4 J	2
Iron	187,000 J	14,000
Selenium	4.7 J	1.5
Zinc	663 J	447
$Diff_{SEM-AVS}$/TOC	-1925.7	

SED-D14-01 (SED-D14-01 DUP)		
Parameter	Result	Benchmark
Arsenic	16.9 J	9.98, 33
Cadmium	0.53 J	2
Iron	50,300 J	14,000
Selenium	6.6 UJ	1.5
Zinc	243 J	447
$Diff_{SEM-AVS}$/TOC	-58.8	

SED-BL14-02		
Parameter	Result	Benchmark
Arsenic	72.8 J	9.98, 33
Cadmium	1.2 J	2
Iron	217,000 J	14,000
Selenium	3.7 J	1.5
Zinc	561 J	447
$Diff_{SEM-AVS}$/TOC	-185.6	

SED-BL14-05		
Parameter	Result	Benchmark
Arsenic	22.1 J	9.98, 33
Cadmium	0.69 J	2
Iron	56,700 J	14,000
Selenium	6.1 UJ	1.5
Zinc	227 J	447
$Diff_{SEM-AVS}$/TOC	-185.9	

SED-BL14-01		
Parameter	Result	Benchmark
Arsenic	9 J	9.98, 33
Cadmium	0.37 J	2
Iron	25,500 J	14,000
Selenium	5 UJ	1.5
Zinc	146 J	447
$Diff_{SEM-AVS}$/TOC	-186.5	

SED-BG14-03		
Parameter	Result	Benchmark
Arsenic	3.6 UJ	9.98, 33
Cadmium	0.85 J	0.6, 10
Iron	1,850 J	---
Selenium	1.5 J	---
Zinc	10.6 UJ	121, 820
$Diff_{SEM-AVS}$/TOC	-2.9	

Briar Lake

Briar Lake Detail

GEMS Landfill

Legend

Sediment Sample

Notes:
All metal concentrations are presented in mg/kg dw.
For arsenic, the benchmarks shown are the NJDEP LEL and SEL values. For cadmium and zinc the background sample benchmarks are the NJDEP LEL and SEL values; the benchmark for the remaining samples is maximum background. For iron and selenium, the benchmarks for Holly Run and Briar Lake is the maximum background. See text for discussion of regarding the sediment benchmarks.
DiffSEM-AVS/TOC = The difference between SEM and AVS, normalized to the total organic carbon content of the co-collected sediments, has units of µmol/gOC.
J = The associated numerical value is an estimated quantity.
U = The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.
UJ = The material was analyzed for, but was not detected. The sample quantitation limit is an estimated quantity.

0 500 1,000
Feet

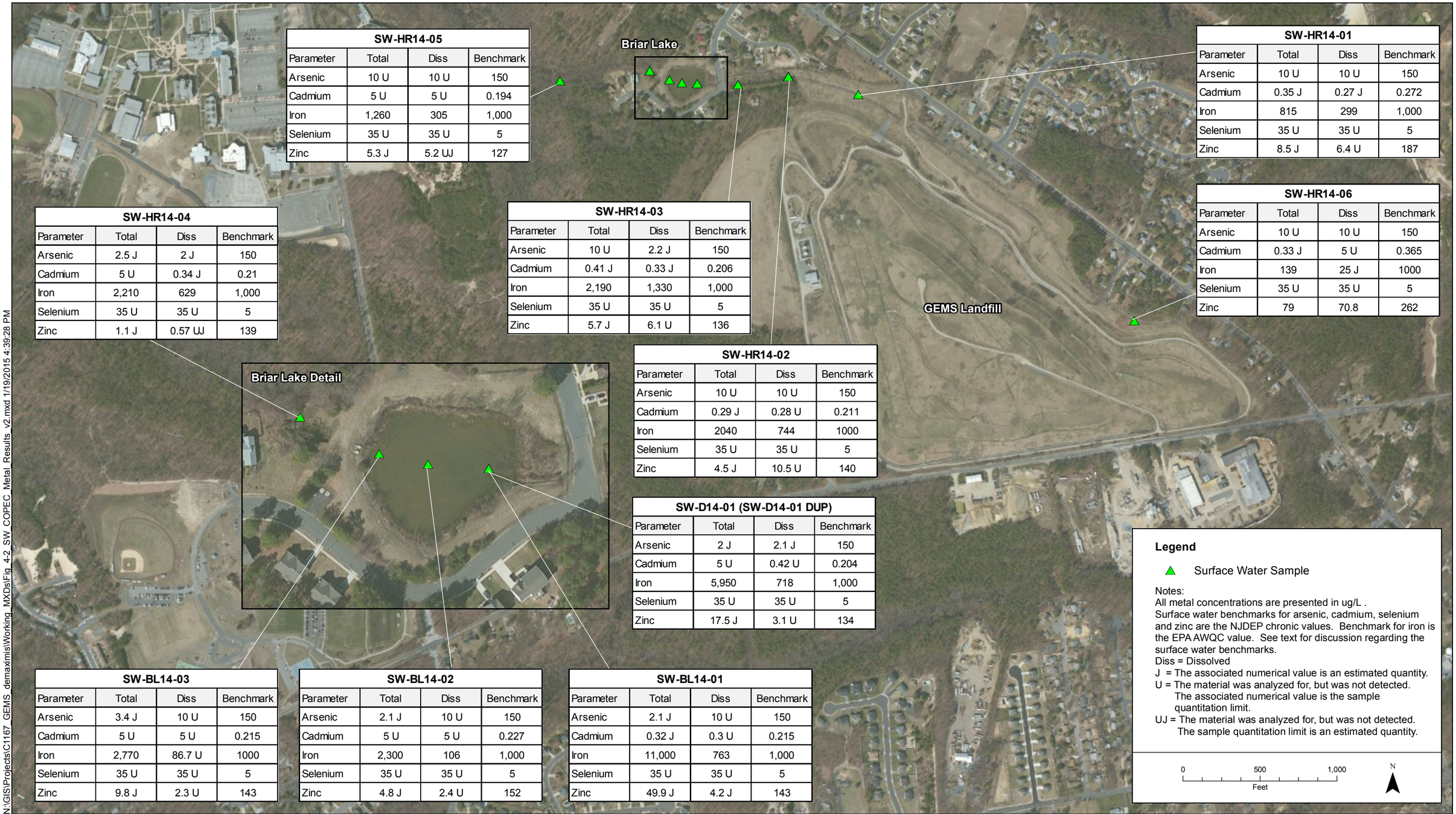
N

N:\GIS\Projects\C1167_GEMS_demaximis\Working_MXDs\Fig_4-1_Sediment_COPEC_Metal_Results_v2.mxd 1/19/2015 4:41:38 PM

Background imagery is for reference purposes only, and is courtesy of ESRI.

integral consulting inc.

Figure 4-1.
Spatial Distribution and Comparison of Sediment COPEC Metal Results to Refined Sediment Benchmarks for Holly Run and Briar Lake (Assessment Endpoint No. 1). GEMS Landfill, Gloucester Township, Camden County, New Jersey



SW-HR14-05			
Parameter	Total	Diss	Benchmark
Arsenic	10 U	10 U	150
Cadmium	5 U	5 U	0.194
Iron	1,260	305	1,000
Selenium	35 U	35 U	5
Zinc	5.3 J	5.2 UJ	127

SW-HR14-01			
Parameter	Total	Diss	Benchmark
Arsenic	10 U	10 U	150
Cadmium	0.35 J	0.27 J	0.272
Iron	815	299	1,000
Selenium	35 U	35 U	5
Zinc	8.5 J	6.4 U	187

SW-HR14-04			
Parameter	Total	Diss	Benchmark
Arsenic	2.5 J	2 J	150
Cadmium	5 U	0.34 J	0.21
Iron	2,210	629	1,000
Selenium	35 U	35 U	5
Zinc	1.1 J	0.57 UJ	139

SW-HR14-03			
Parameter	Total	Diss	Benchmark
Arsenic	10 U	2.2 J	150
Cadmium	0.41 J	0.33 J	0.206
Iron	2,190	1,330	1,000
Selenium	35 U	35 U	5
Zinc	5.7 J	6.1 U	136

SW-HR14-06			
Parameter	Total	Diss	Benchmark
Arsenic	10 U	10 U	150
Cadmium	0.33 J	5 U	0.365
Iron	139	25 J	1000
Selenium	35 U	35 U	5
Zinc	79	70.8	262

SW-HR14-02			
Parameter	Total	Diss	Benchmark
Arsenic	10 U	10 U	150
Cadmium	0.29 J	0.28 U	0.211
Iron	2040	744	1000
Selenium	35 U	35 U	5
Zinc	4.5 J	10.5 U	140

SW-D14-01 (SW-D14-01 DUP)			
Parameter	Total	Diss	Benchmark
Arsenic	2 J	2.1 J	150
Cadmium	5 U	0.42 U	0.204
Iron	5,950	718	1,000
Selenium	35 U	35 U	5
Zinc	17.5 J	3.1 U	134

SW-BL14-03			
Parameter	Total	Diss	Benchmark
Arsenic	3.4 J	10 U	150
Cadmium	5 U	5 U	0.215
Iron	2,770	86.7 U	1000
Selenium	35 U	35 U	5
Zinc	9.8 J	2.3 U	143

SW-BL14-02			
Parameter	Total	Diss	Benchmark
Arsenic	2.1 J	10 U	150
Cadmium	5 U	5 U	0.227
Iron	2,300	106	1,000
Selenium	35 U	35 U	5
Zinc	4.8 J	2.4 U	152

SW-BL14-01			
Parameter	Total	Diss	Benchmark
Arsenic	2.1 J	10 U	150
Cadmium	0.32 J	0.3 U	0.215
Iron	11,000	763	1,000
Selenium	35 U	35 U	5
Zinc	49.9 J	4.2 J	143

Legend

▲ Surface Water Sample

Notes:
All metal concentrations are presented in ug/L .
Surface water benchmarks for arsenic, cadmium, selenium and zinc are the NJDEP chronic values. Benchmark for iron is the EPA AWQC value. See text for discussion regarding the surface water benchmarks.
Diss = Dissolved
J = The associated numerical value is an estimated quantity.
U = The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation limit.
UJ = The material was analyzed for, but was not detected. The sample quantitation limit is an estimated quantity.

0 500 1,000
Feet

N

N:\GIS\Projects\C1167_GEMS_demaximis\Working_MXDs\Fig_4-2_SW_COPEC_Metal_Results_v2.mxd 1/19/2015 4:39:28 PM

Background imagery is for reference purposes only, and is courtesy of ESRI.

integral consulting inc.

Figure 4-2.
Spatial Distribution and Comparison of Surface Water COPEC Metal Results to Benchmarks for Holly Run and Briar Lake (Assessment Endpoint Nos. 2 and 3). GEMS Landfill, Gloucester Township, Camden County, New Jersey

TABLES

Table 1-1. Chemicals of Potential Ecological Concern Identified in the EPA SLERA

Chemical Group	Holly Run	Briar Lake
Metals	Barium Cadmium[a] Iron Selenium	Arsenic[a] Barium Cadmium[a] Chromium Copper Iron[a] Mercury Selenium[a] Zinc[a]
VOCs	Acetone	Acetone Chlorobenzene
SVOCs	Acenaphthene Naphthalene	Bis(2-ethylhexyl) phthalate

[a]The EPA letter of June 20, 2013, specifically mentions concentrations of cadmium, arsenic, iron, selenium and zinc in sediment exceeded ecological benchmarks and background values, as a basis for performing the BERA.

Table 2-1. Surface Sediment and Surface Water Locations for the October 2014 Field Investigation near the GEMS Landfill

Parcel	Station	Recorded Latitude	Recorded Longitude	Surface Sediment Sample ID (0 - 6 inches)	Surface Water Sample ID	Comment
Background	BG-01	39.7808	-75.0158	--	--	
Background	BG-03	39.7749	-75.0234	SED-BG14-03	--	
Background	BG-04	39.7817	-75.0280	SED-BG14-04	--	The recorded sampling coordinates at BG-04 are approximate to within 5 meters as a result of high position dilution of percision (PDOP) under the forest canopy.
Background	BG-05	39.7808	-75.0155	SED-BG14-05	--	
Holly Run	HR-01	39.7848	-75.0227	--	SW-HR14-01	
Holly Run	HR-02	39.7852	-75.0244	--	SW-HR14-02 [SW-HR14-02MS]	
Holly Run	HR-03	39.7850	-75.0255	--	SW-HR14-03	
Holly Run	HR-04	39.7852	-75.0276	SED-HR14-04	SW-HR14-04	
Holly Run	HR-05	39.7851	-75.0296	SED-HR14-05	SW-HR14-05	
Holly Run	HR-06	39.7808	-75.0163	--	SW-HR14-06	New location identified in the field as being downgradient of BG-01 where surface water was present in Holly Run channel.
Briar Lake	BL-01	39.7850	-75.0265	SED-BL14-01 [SED-BL14-01MS]	SW-BL14-01	
Briar Lake	BL-02	39.7850	-75.0268	SED-BL14-02	SW-BL14-02	
Briar Lake	BL-03	39.7851	-75.0271	SED-BL14-03	SW-BL14-03	
Briar Lake	BL-04	39.7852	-75.0267	SED-BL14-04	--	
Briar Lake	BL-05	39.7847	-75.0269	SED-BL14-05	--	
Field Duplicate	D14-01 (BL-01)	NA	NA	SED-D14-01	SW-D14-01	Field QC sample

Notes:

The cordinatges were measured in the field using global positioning system. Locations were altered in the field to account for accessibility, co-location with NJDEP and/or availability of media of interest.

SED = Sediment sample

SW = Surface water sample

-- Sample not collected at this station due to insufficient media or not proposed in Work Plan Technical Memorandum (Integral 2014a).

Table 2-2. Summary of Surface Sediment Inorganic and General Parameter Results from Holly Run, Briar Lake, and Background Location Samples Collected in October 2014

		Background				Briar Lake				Holly Run			
Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects
Inorganics													
Aluminum	mg/kg_{dw}	3/3	3,173	2,180 - 3,900	---	6/6	6,322	1,940 - 11,300	---	2/2	1,288	736 - 1,840	---
Antimony	mg/kg_{dw}	2/3	0.55 *	0.42 - 0.55	16.2 - 16.2	6/6	2.5	0.82 - 3.8	---	0/2	---	---	6.3 - 10
Arsenic	mg/kg_{dw}	1/3	2.0	3.2 - 3.2	1.7 - 3.6	6/6	42	9 - 72.8	---	2/2	1.65	1.6 - 1.7	---
Barium	mg/kg_{dw}	2/3	96	34.4 - 252	5.6 - 5.6	6/6	94	37.7 - 143	---	1/2	21	35.4 - 35.4	13.8 - 13.8
Beryllium	mg/kg_{dw}	0/3	---	---	0.21 - 1.1	1/6	0.6	2.2 - 2.2	0.18 - 1.2	2/2	0.31	0.045 - 0.57	---
Cadmium	mg/kg_{dw}	3/3	1.1	0.34 - 2	---	6/6	0.9	0.37 - 1.4	---	1/2	0.51	0.97 - 0.97	0.11 - 0.11
Calcium	mg/kg_{dw}	1/3	1,680	4,770 - 4,770	18.9 - 519	6/6	5,475	3,520 - 6,650	---	0/2	---	---	108 - 798
Chromium	mg/kg_{dw}	3/3	9.4	6.4 - 12.5	---	6/6	18	8.8 - 26.2	---	2/2	4.3	3.2 - 5.4	---
Cobalt	mg/kg_{dw}	3/3	1.3	0.15 - 1.8	---	6/6	3.6	1.5 - 6.8	---	2/2	0.35	0.34 - 0.36	---
Copper	mg/kg_{dw}	3/3	6.2	1.5 - 14.5	---	6/6	21.1	14.3 - 32.4	---	2/2	1.7	1.3 - 2	---
Iron	mg/kg_{dw}	3/3	5,640	1,070 - 14,000	---	6/6	121,250	25,500 - 217,000	---	2/2	3,545	2,620 - 4,470	---
Lead	mg/kg_{dw}	3/3	15	7.7 - 20.9	---	6/6	20.9	7.5 - 35.2	---	2/2	3.9	3.2 - 4.6	---
Magnesium	mg/kg_{dw}	3/3	917	17.1 - 2,460	---	6/6	2,127	1,640 - 3,390	---	2/2	179	65.7 - 292	---
Manganese	mg/kg_{dw}	3/3	58	10.8 - 144	---	6/6	219	66.5 - 396	---	2/2	14	8.4 - 18.7	---
Mercury	mg/kg_{dw}	2/3	0.13	0.11 - 0.27	0.018 - 0.018	3/6	0.28	0.3 - 0.71	0.042 - 0.13	0/2	---	---	0.0094 - 0.027
Nickel	mg/kg_{dw}	3/3	4.6	0.61 - 6.8	---	6/6	8.1	5 - 12.6	---	0/2	---	---	0.47 - 3.1
Potassium	mg/kg_{dw}	0/3	---	---	55.6 - 388	0/6	---	---	228 - 907	2/2	65	48.8 - 80.7	---
Selenium	mg/kg_{dw}	1/3	1.5 *	1.5 - 1.5	3.2 - 5.5	3/6	3.6	3.7 - 4.7	5 - 6.6	1/2	1 *	1 - 1	3.7 - 3.7
Vanadium	mg/kg_{dw}	2/3	8.7	8.8 - 14.5	5.5 - 5.5	6/6	27	9.3 - 40.4	---	2/2	4.3	3.2 - 5.3	---
Zinc	mg/kg_{dw}	1/3	151	447 - 447	3.9 - 10.6	6/6	413	146 - 663	---	1/2	6.9	10.4 - 10.4	6.6 - 6.6
General Parameters													
Sediment pH	SU	3/3	5.66	4.68 - 6.3	---	6/6	6.76	6.63 - 6.99	---	2/2	5.72	5.43 - 6.01	---
Percent Solids	%	3/3	54.7	28.1 - 83	---	6/6	36.6	20.2 - 52.4	---	2/2	65.1	52.4 - 77.7	---
Total Organic Carbon	mg/kg_{dw}	3/3	58,410	7,830 - 143,000	---	6/6	58,017	18,700 - 101,000	---	2/2	15,135	5,670 - 24,600	---
Total Organic Carbon	%	3/3	5.84	0.78 - 14.3	---	6/6	5.8	1.87 - 10.1	---	2/2	1.51	0.56 - 2.46	---
Corresponding Samples		SED-BG14-03, SED-BG14-04, and SED-BG14-05				SED-BL14-01, SED-D14-01 (SED-BL14-01 Dup), SED-BL14-02, SED-BL14-03, SED-BL14-04, and SED-BL14-05				SED-HR14-04 and SED-HR14-05			

Notes:
Only those chemicals detected in at least one of the samples are shown in this table.
The field duplicate of SED-BL14-01 (SED-D14-01) was treated as an independent sample in this summary.
Individual sample results are provided in Appendix D, Table D-2a.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit.

Table 2-3. Summary of Surface Sediment AVS and SEM Results from Holly Run, Briar Lake, and Background Location Samples Collected in October 2014

		Background				Holly Run				Briar Lake			
Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects
Acid Volatile Sulfide	µmoles/g	1/2	0.89	0.93 - 0.93	1.7 - 1.7	1/2	3.9	7.4 - 7.4	0.64 - 0.64	6/6	38.1	5.9 - 166	-
SEM-Cadmium	µmoles/g	1/2	0.0098 *	0.0098 - 0.0098	0.037 - 0.037	1/2	0.0055	0.0039 - 0.0039	0.014 - 0.014	5/6	0.008	0.0033 - 0.014	---
SEM-Copper	µmoles/g	0/2	---	---	0.18 - 0.34	1/2	0.014 *	0.014 - 0.014	0.18 - 0.18	6/6	0.20	0.061 - 0.33	---
SEM-Lead	µmoles/g	1/2	0.0015 *	0.015 - 0.015	0.042 - 0.042	2/2	0.019	0.011 - 0.026	---	6/6	0.10	0.03 - 0.2	---
SEM-Mercury	µmoles/g	2/2	0.00019	0.00013 - 0.00024	---	2/2	0.000014	0.000013 - 0.000015	---	6/6	0.00008	0.000017 - 0.00019	---
SEM-Nickel	µmoles/g	0/2	---	---	0.32 - 0.59	1/2	0.066	0.021 - 0.021	0.22 - 0.22	6/6	0.09	0.031 - 0.18	---
SEM-Zinc	µmoles/g	0/2	---	---	0.14 - 0.27	2/2	0.10	0.1 - 0.1	---	6/6	5.7	1.5 - 11.8	---
Sum SEM	µmoles/g	2/2	0.0126	0.00013 - 0.025	---	2/2	0.138	0.125 - 0.151	---	6/6	6.1	1.62 - 12.52	---
Corresponding Samples		SED-BG14-03 and SED-BG14-04				SED-HR14-04 and SED-HR14-05				SED-BL14-01, SED-D14-01 (SED-BL14-01 Dup), SED-BL14-02, SED-BL14-03, SED-BL14-04, and SED-BL14-05			

Notes:
The field duplicate of SED-BL14-01 (SED-D14-01) was treated as an independent sample in this summary.
Individual sample results are provided in Appendix D, Table D-4.
Sum SEM is sum of the detected results for the individual SEM metals.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit.
*: Calculated average exceeded maximum detection. Latter is shown as average value.

Table 2-4. Summary of Surface Sediment Grain Size Results from Holly Run, Briar Lake, and Background Location Samples Collected in October 2014

			Background				Holly Run				Briar Lake			
Group	Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects
Sieve	% Gravel	%	1/3	0.5	1.5 - 1.5	0 - 0	1/2	2	3.2 - 3.2	0 - 0	0/6	0	-	0 - 0
	% Sand	%	3/3	77	64.2 - 86.7	-	2/2	85	80 - 90	-	6/6	40.4	6.1 - 77.8	-
	% Coarse Sand	%	3/3	3.8	2.3 - 5.8	-	2/2	3	1.8 - 4.2	-	5/6	2.1	0.8 - 5.6	0 - 0
	% Medium Sand	%	3/3	21	9.5 - 40.6	-	2/2	28	27.1 - 29.1	-	6/6	9.0	1 - 20.9	-
	% Fine Sand	%	3/3	52	40.3 - 67.4	-	2/2	54	51.1 - 56.7	-	6/6	29.3	4.3 - 52.4	-
	% Clay	%	3/3	2.9	1.5 - 4	-	2/2	3.4	2 - 4.8	-	6/6	12.4	4.3 - 24.2	-
	% Silt	%	3/3	20	7.8 - 32.5	-	2/2	10	4.8 - 15.2	-	6/6	47.2	17.6 - 81.4	-
	Sieve Size #4	%	1/3	0.5	1.5 - 1.5	0 - 0	1/2	2	3.2 - 3.2	0 - 0	0/6	0.0	-	0 - 0
	Sieve Size #10	%	3/3	3.8	2.3 - 5.8	-	2/2	3	1.8 - 4.2	-	5/6	2.1	0.8 - 5.6	0 - 0
	Sieve Size #20	%	3/3	7.7	3.7 - 13.1	-	2/2	12	9.3 - 14.3	-	6/6	4.1	0.6 - 8.9	-
	Sieve Size #40	%	3/3	13	5.8 - 27.5	-	2/2	16	12.8 - 19.8	-	6/6	4.8	0.4 - 12.2	-
	Sieve Size #60	%	3/3	10	4.8 - 18	-	2/2	11	6.5 - 15.2	-	6/6	4.8	0.5 - 11.2	-
	Sieve Size #80	%	3/3	9.3	9.1 - 9.4	-	2/2	10	7.6 - 11.5	-	6/6	5.4	0.4 - 11.4	-
	Sieve Size #100	%	3/3	11	5.6 - 15.5	-	2/2	10	9.2 - 10.7	-	6/6	4.9	0.4 - 9.4	-
	Sieve Size #200	%	3/3	22	7.3 - 37.7	-	2/2	24	19.3 - 27.8	-	6/6	14.3	2.3 - 29.5	-
Hydrometer	Hydrometer Reading 1	%	3/3	15	4.1 - 21.7	-	2/2	7.3	3.9 - 10.7	-	6/6	20.2	7.3 - 33.3	-
	Hydrometer Reading 1 - Particle Size	µm	3/3	35	34.7 - 36.1	-	2/2	35.7	35.2 - 36.2	-	6/6	30.2	25.7 - 35.4	-
	Hydrometer Reading 2	%	2/3	3.1	1 - 8.4	0 - 0	1/2	0.8	1.5 - 1.5	0 - 0	6/6	11.4	1.6 - 20	-
	Hydrometer Reading 2 - Particle Size	µm	3/3	23	22.2 - 22.8	-	2/2	22.7	22.5 - 22.9	-	6/6	20.4	18.7 - 22.6	-
	Hydrometer Reading 3	%	2/3	0.5	0.5 - 1	0 - 0	2/2	0.7	0.5 - 0.8	-	5/6	9.3	0.8 - 36.9	0 - 0
	Hydrometer Reading 3 - Particle Size	µm	3/3	13	12.9 - 13.2	-	2/2	13.2	13 - 13.3	-	6/6	12.3	11.3 - 13.1	-
	Hydrometer Reading 4	%	2/3	0.8	1.1 - 1.2	0 - 0	2/2	1.0	0.5 - 1.5	-	5/6	3.6	0.9 - 6.4	0 - 0
	Hydrometer Reading 4 - Particle Size	µm	3/3	9.3	9.1 - 9.4	-	2/2	9.2	9 - 9.4	-	6/6	8.7	8.1 - 9.4	-
	Hydrometer Reading 5	%	2/3	0.6	0.5 - 1.2	0 - 0	1/2	0.4	0.8 - 0.8	0 - 0	4/6	2.7	2.5 - 5.6	0 - 0
	Hydrometer Reading 5 - Particle Size	µm	3/3	6.6	6.5 - 6.7	-	2/2	6.6	6.5 - 6.6	-	6/6	6.4	6 - 6.7	-
	Hydrometer Reading 6	%	3/3	0.8	0.4 - 1	-	2/2	1.0	0.9 - 1	-	6/6	2.6	0.6 - 6.1	-
	Hydrometer Reading 6 - Particle Size	µm	3/3	3.3	3.3 - 3.3	-	2/2	3.3	3.2 - 3.3	-	6/6	3.2	3 - 3.4	-
	Hydrometer Reading 7	%	3/3	1.1	0.7 - 1.5	-	1/2	0.4	0.8 - 0.8	0 - 0	6/6	3.15	1 - 7.7	-
	Hydrometer Reading 7 - Particle Size	µm	3/3	1.4	1.4 - 1.4	-	2/2	1.4	1.4 - 1.4	-	6/6	1.4	1.3 - 1.4	-
	Corresponding Samples		SED-BG14-03, SED-BG14-04 and SED-BG14-05				SED-HR14-04 and SED-HR14-05				SED-BL14-01, SED-D14-01 (SED-BL14-01 Dup), SED-BL14-02, SED-BL14-03, SED-BL14-04, and SED-BL14-05			

Notes:
Only those chemicals detected in at least one of the samples are shown in this table.
The field duplicate of SED-BL14-01 (SED-D14-01) was treated as an independent sample in this summary.
Individual sample results are provided in Appendix D, Table D-5.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit (zero in the case of grain size).

Table 2-5a. Summary of Inorganic Analytical Results for Unfiltered Surface Water Samples Collected from Holly Run and Briar Lake in October 2014

		Holly Run				Briar Lake				
Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects	COPEC Metal
Aluminum	µg/L	5/6	57	31.9 - 65.6	200 - 200	3/4	98	78.2 - 130	200 - 200	No
Arsenic	µg/L	1/6	2.5 *	2.5 - 2.5	10 - 10	4/4	2.4	2 - 3.4	---	Yes
Cadmium	µg/L	3/6	0.41 *	0.33 - 0.41	0.29 - 5	0/4	---	---	0.32 - 5	Yes
Calcium	µg/L	6/6	38,517	25,300 - 78,700	---	4/4	28,600	26,100 - 31,300	---	No
Chromium	µg/L	4/6	0.49 *	0.39 - 0.49	0.26 - 10	4/4	0.6	0.35 - 0.81	---	No
Cobalt	µg/L	0/6	---	---	50 - 50	1/4	0.9 *	0.9 - 0.9	50 - 50	No
Copper	µg/L	1/6	3 *	3 - 3	25 - 25	1/4	4.4 *	4.4 - 4.4	25 - 25	No
Iron	µg/L	6/6	2,210 *	139 - 2,210	---	4/4	5,505	2,300 - 11,000	---	Yes
Magnesium	µg/L	6/6	14,667	12,400 - 17,500	---	4/4	14,450	13,700 - 15,200	---	No
Manganese	µg/L	6/6	52	25.1 - 92.6	---	4/4	105	49.1 - 171	---	No
Nickel	µg/L	3/6	1.4 *	1.2 - 1.4	40 - 40	2/4	1.3 *	1.2 - 1.3	40 - 40	No
Potassium	µg/L	6/6	4,325	1,650 - 6,370	---	4/4	5,460	4,990 - 6,530	---	No
Selenium	µg/L	0/6	---	---	35 - 35	0/4	---	---	35 - 35	Yes
Sodium	µg/L	6/6	27,317	7,600 - 42,600	---	4/4	41,200	36,100 - 52,000	---	No
Thallium	µg/L	1/6	2.6 *	2.6 - 2.6	25 - 25	1/4	2.7 *	2.7 - 2.7	25 - 25	No
Vanadium	µg/L	0/6	---	---	50 - 50	4/4	0.8	0.69 - 1.1	---	No
Zinc	µg/L	1/6	15	79 - 79	1.1 - 8.5	0/4	---	---	4.8 - 49.9	Yes
General Parameters										
Calculated Hardness	mg/L	6/6	157	114 - 267	---	4/4	131	122 - 141	---	
Corresponding Samples		SW-HR14-01, SW-HR14-02, SW-HR14-03, SW-HR14-04, SW-HR14-05, and SW-HR14-06				SW-BL14-01, SW-D14-01 (SW-BL14-01 Dup), SW-BL14-02, and SW-BL14-03				

Notes:
Only those chemicals detected in at least one of the samples are shown in this table (unless it was a COPEC chemical).
No surface water was present at the background sampling locations.
The field duplicate of SW-BL14-01 (SW-D14-01) was treated as an independent sample in this summary.
Individual sample results are provided in Appendix D, Table D-7a.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit.
* Indicates calculated mean exceeds maximum detected result. Latter is shown as average value.

Table 2-5b. Summary of Inorganic and General Parameter Analytical Results for Filtered Surface Water Samples Collected from Holly Run and Briar Lake in October 2014

		Holly Run				Briar Lake				
Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects	COPEC Metal
Inorganics										
Aluminum	µg/L	4/6	34.3 *	28.4 - 34.3	200 - 200	2/4	29.7 *	29.2 - 29.7	200 - 200	No
Arsenic	µg/L	2/6	2.2 *	2 - 2.2	10 - 10	1/4	2.1 *	2.1 - 2.1	10 - 10	Yes
Cadmium	µg/L	3/6	0.34 *	0.27 - 0.34	0.28 - 5	0/4	---	---	0.3 - 5	Yes
Calcium	µg/L	6/6	38,717	23,000 - 77,300	---	4/4	26,525	25,200 - 29,200	---	No
Chromium	µg/L	4/6	0.47 *	0.32 - 0.47	9.5 - 10	3/4	0.43 *	0.26 - 0.43	10 - 10	No
Cobalt	µg/L	0/6	---	---	50 - 50	1/4	0.79 *	0.79 - 0.79	50 - 50	No
Copper	µg/L	1/6	3 *	3 - 3	25 - 25	0/4	---	---	25 - 25	No
Iron	µg/L	6/6	555	25 - 1,330	---	3/4	408	106 - 763	86.7 - 86.7	Yes
Magnesium	µg/L	6/6	14,850	11,300 - 17,200	---	4/4	13,550	12,600 - 14,300	---	No
Manganese	µg/L	5/6	46	24.5 - 99.9	11.8 - 11.8	4/4	87	40.1 - 129	---	No
Nickel	µg/L	2/6	1.4 *	1.2 - 1.4	40 - 40	1/4	1.4 *	1.4 - 1.4	40 - 40	No
Potassium	µg/L	6/6	4,455	1,620 - 6,810	---	4/4	5,138	4,440 - 6,130	---	No
Selenium	µg/L	0/6	---	---	35 - 35	0/4	---	---	35 - 35	Yes
Sodium	µg/L	6/6	28,297	7,380 - 46,300	---	4/4	38,700	3,1800 - 48,700	---	No
Thallium	µg/L	0/6	---	---	25 - 25	3/4	3.4 *	2.1 - 3.4	25 - 25	No
Zinc	µg/L	1/6	14	70.8 - 70.8	0.57 - 10.5	0/4	---	---	2.3 - 4.2	Yes
General Parameters										
Dissolved Organic Carbon	mg/L	4/6	7.0	7.5 - 11.1	5.2 - 6	3/4	6.5	7.4 - 7.6	6.9 - 6.9	
Calculated Hardness	mg/L	6/6	158	104 - 263	---	4/4	122	115 - 132	---	
Corresponding Samples		SW-HR14-01, SW-HR14-02, SW-HR14-03, SW-HR14-04, SW-HR14-05, and SW-HR14-06				SW-BL14-01, SW-D14-01 (SW-BL14-01 Dup), SW-BL14-02, and SW-BL14-03				

Notes:
Only those chemicals detected in at least one of the samples are shown in this table (unless it was a COPEC chemical).
The field duplicate of SW-BL14-01 (SW-D14-01) was treated as an independent sample in this summary.
Individual sample results are provided in Appendix D, Table D-7b.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit.
* Indicates calculated mean exceeds maximum detected result. Latter is shown as average value.

Table 2-6. Summary of Surface Water Quality Field Measurements from Holly Run and Briar Lake in October 2014

		Holly Run				Briar Lake			
Parameter	Units	DetFreq	Avg	Range of Positives	Range of Non-Detects	DetFreq	Avg	Range of Positives	Range of Non-Detects
Conductivity	mS/cm	6/6	0.50	0.405 - 0.6	---	3/3	0.52	0.46 - 0.566	---
DO	mg/L	6/7	5.63	3.84 - 8.66	---	3/3	4.10	2.88 - 6.08	---
DO%	%	6/8	58.00	42 - 91.8	---	3/3	43.4	31.6 - 62.2	---
Field pH	SU	6/9	6.94	6.71 - 7.28	---	3/3	6.99	6.89 - 7.08	---
ORP	mV	6/10	50.9	-11 - 136.6	---	3/3	109	51.5 - 182.4	---
Temperature	^{o}C	6/11	15.9	14.06 - 18.29	---	3/3	17.1	15.12 - 18.16	---
Turbidity	NTU	6/12	14.6	6.7 - 23.1	---	3/3	32.8	15.6 - 60.3	---

Notes:

There was no surface water present at any of the background sampling locations at the time of sampling.

Table 2-7. Summary of COPEC Metal Analytical Results for Unfiltered Shallow Groundwater Collected Near Holly Run

Piezometer	Parameter	DetFreq	Avg	Range of Positives	Range of Non-Detects	Well Depth (ft)	Top of Screen Depth GS (ft)	Bottom of Screen Depth GS (ft)
PM-12	Arsenic	8/14	3.3	2.4 - 8.7	3.2 - 5	19	4	19
	Cadmium	0/14	---	---	0.4 - 5			
	Iron	5/5	30,840	21,200 - 52,300	-			
	Selenium	0/5	---	---	2.5 - 5			
	Zinc	2/5	12.0	10.5 - 16.6	5.8 - 30			
PM-18	Arsenic	0/1	---	---	2.5 - 2.5	49	39	49
	Cadmium	0/1	---	---	2.5 - 2.5			
	Iron	1/1	146	146 - 146	-			
	Selenium	0/1	---	---	2.5 - 2.5			
	Zinc	0/1	---	---	20 - 20			
PM-19	Arsenic	13/13	112	66.8 - 230	-	18	3	18
	Cadmium	0/13	---	---	0.4 - 5			
	Iron	4/4	74,175	55,500 - 95,200	-			
	Selenium	1/4	2.8	2.3 - 2.3	4.2 - 8.4			
	Zinc	2/4	10.4	9.5 - 16.4	11.6 - 20			
PM-24	Arsenic	6/13	3.3	3.2 - 9.9	2.5 - 5	19	4	19
	Cadmium	0/13	---	---	0.4 - 5			
	Iron	4/4	4,224	334 - 8,510	-			
	Selenium	0/4	---	---	2.5 - 5			
	Zinc	4/4	33.3	19.8 - 44.9	-			
PM-25	Arsenic	6/14	3.0	2 - 6.5	2.5 - 6.4	19	4	19
	Cadmium	0/14	---	---	0.4 - 5			
	Iron	4/4	7,515	429 - 16,000	-			
	Selenium	0/4	---	---	2.5 - 8.4			
	Zinc	4/4	187	17.4 - 440	-			

Notes:
All concentration units are in µg/L.
Average concentrations were calculated by setting non-detect results to one-half the reported detection limit.
Top and Bottom of Screen Intervals are related to ground surface (GS). All piezometers were screened in the Upper Cohansey aquifer.

Table 2-8. Inorganic and General Parameter Analytical Results for Treatment Plant Influent Samples from Holly Run Collected in 2002

Parameter	Units	Sampling Events					COPEC Metal
		8/13/2002	9/10/2002	10/8/2002	11/5/2002	12/10/2002	
Inorganics							
Aluminum	µg/L	NR	NR	NR	NR	NR	No
Antimony	µg/L	NR	NR	NR	NR	NR	No
Arsenic	µg/L	NR	14.2	10.7	9.6	5.7	Yes
Barium	µg/L	NR	NR	NR	NR	NR	No
Beryllium	µg/L	NR	NR	NR	NR	NR	No
Cadmium	µg/L	NR	NR	NR	NR	NR	Yes
Calcium	µg/L	NR	NR	NR	NR	NR	No
Chromium	µg/L	NR	ND	ND	ND	ND	No
Cobalt	µg/L	NR	NR	NR	NR	NR	No
Copper	µg/L	NR	NR	NR	NR	NR	No
Iron	µg/L	NR	8,150	11,800	16,700	9,510	Yes
Lead	µg/L	NR	NR	NR	NR	NR	No
Magnesium	µg/L	NR	NR	NR	NR	NR	No
Manganese	µg/L	NR	NR	NR	NR	NR	No
Mercury	µg/L	NR	NR	NR	NR	NR	No
Nickel	µg/L	NR	ND	ND	4.6	NR	No
Potassium	µg/L	33,300	30,200	25,700	26,600	25,100	No
Selenium	µg/L	NR	NR	NR	NR	NR	Yes
Silver	µg/L	NR	NR	NR	NR	NR	No
Sodium	µg/L	NR	NR	NR	NR	NR	No
Thallium	µg/L	NR	NR	NR	NR	NR	No
Vanadium	µg/L	NR	NR	NR	NR	NR	No
Zinc	µg/L	NR	13.8	15.4	27.5	15.1	Yes
General Parameters							
Hardness (as $CaCO_3$)	mg/L	NR	NR	NR	NR	NR	
Ammonia	mg/L	36.2	27.2	21.6	23.7	21.8	
BOD	mg/L	10.7	6.9	ND	5.9	5.3	
COD	mg/L	126	82.2	63.9	81.8	62.1	
Sulfate	mg/L	9.9	18.5	18.9	58.1	14.7	
Total Dissolved Solids	mg/L	984	598	483	434	384	
Total Suspended Solids	mg/L	34	ND	18	32	11	
Total Petroleum Hydrocarbon	mg/L	NR	NR	NR	NR	NR	

Notes:
Samples were influents to the on-site treatment plant from Holly Run.
NR: Not reported.
ND: Not detected. Detection limits were not reported.

Table 3-1. Comparison of Unfiltered and Filtered Surface Water Results for Locations that Potentially Receive Off-Property Inputs

Parameter	SW-HR14-01	SW-HR14-02
Arsenic	10 U	10 U
Cadmium	0.35 J	0.29 U
Iron	815	2,040
Selenium	35 U	35 U
Zinc	8.5 U	4.5 U
Arsenic-Diss	10 U	10 U
Cadmium-Diss	0.27 J	0.28 U
Iron-Diss	299	744
Selenium-Diss	35 U	35 U
Zinc-Diss	6.4 U	10.5 U

Notes:
HR-02 is located near a storm drain that receives inputs from Erial Road.
All concentration units are in μg/L.
Data qualiers: U = not detected; J = estimated concentration at value shown.

Table 3-2. Literature Values for Plant and Invertebrate Uptake Factors from Sediments

COPEC Metal	Plant Uptake Factor ($B_{v)}$	Sediment to Invertebrate Bioconcentration Factor
Arsenic	0.04	0.9
Cadmium	0.55	3.4
Iron	0.004	NV
Selenium	0.025	0.9
Zinc	1.5	0.57

Notes:

The plant uptake factor is from Baes et al (1984).

The sediment to invertebrate bioconcentration factors are from USEPA (1999b).

NV: No value available.

Table 4-1. Summary of Benthic Invertebrate Benchmarks used for the Evaluation of Surface Sediment Results

	NJDEP Sediment Criteria (NJDEP 2009)		Consensus Benchmarks		Site-Specific Background		USGS NURE Sediment Data		
Parameter	Lowest Effects Level (LEL)	Severe Effects Level (SEL)	TEC	PEC	Average	Range	Average	Range	COPEC Metal
Inorganics									
Aluminum	25,500	NV	NV	NV	3,173	2,180 to 3,900	39,827	1,000 to 96,000	No
Antimony	NV	3	NV	NV	0.55 *	ND to 0.55	NR	NR	No
Arsenic	9.98	33	9.79	33	2.0	ND to 3.2	3.6	1.0 to 16	Yes
Barium	NV	NV	NV	NV	96	ND to 252	100	5 to 548	No
Beryllium	NV	NV	NV	NV	ND	ND	1.4	0.5 to 3.5	No
Cadmium	0.6	10	0.99	4.98	1.1	0.34 to 2	NR	NR	Yes
Calcium	NV	NV	NV	NV	1,680	ND to 4,770	385	100 to 90,000	No
Chromium	NV	NV	43.4	111	9	6.4 to 12.5	9.4	5 to 88	No
Cobalt	50	NV	NV	NV	1.3	0.15 to 1.8	11	5 to 40	No
Copper	31.6	110	31.6	149	6.2	1.5 to 14.5	17	2 to 196	No
Iron	NV	NV	NV	NV	5,640	1,070 to 14,000	40,073	6,000 to 171,000	Yes
Lead	35.8	250	35.8	128	15	7.7 to 20.9	46	12 to 245	No
Magnesium	NV	NV	NV	NV	917	17.1 to 2,460	2,692	500 to 11,000	No
Manganese	630	1,100	NV	NV	58	10.8 to 144	1,278	170 to 6,120	No
Mercury	0.174	2	0.18	1.06	0.13	ND to 0.27	NR	NR	No
Nickel	22.7	75	22.7	48.6	4.6	0.61 to 6.8	15	5 to 58	No
Potassium	NV	NV	NV	NV	ND	ND	12,662	1,000 to 34,000	No
Selenium	NV	NV	NV	NV	1.5 *	ND to 1.5	0.9	1 to 4	Yes
Silver	1	3.7	NV	NV	ND	ND	0.28	0.1 to 0.7	No
Sodium	NV	NV	NV	NV	ND	ND	9,186	100 to 28,000	No
Thallium	NV	NV	NV	NV	ND	ND	NR	NR	No
Vanadium	NV	NV	NV	NV	8.7	ND to 14.5	90	10 to 740	No
Zinc	121	820	121	459	151	ND to 447	144	5 to 1,103	Yes

Notes:

All concentration units are in mg/kg_{dw}.

Consensus sediment benchmarks from MacDonald et al (2000).

The USGS NUREG Sediment Data for New Jersey is discussed in Appendix G.

Average concentrations were calculated by setting non-detect results to one-half the reported detection limit

*: Indicates the calculated average was greater than the maximum observed result. The latter is used to represent the average concentration

ND: Not detetected.

NR: Not reported.

NV: No value.

PEC: Probable Effect Concentration.

TEC: Threshold Effect Concentration.

Table 4-2. Summary of Benchmarks for Evaluation of Surface Water Results

		NJDEP SW Criteria[a]			EPA AWQC[b]			Suter and Tsao (1996)		EPA ECOTOX Database No Effect Levels[c]			
Parameter	Units	Acute	Chronic		Acute	Chronic		EC_{20} Trout	EC_{20} Daphnids	Geomean	Range	COPEC Metal	Comment
Aluminum	µg/L	NV	NV		750	87		4,700	540	NA	NA	No	
Antimony	µg/L	NV	80		NV	NV		2,310	1,900	NA	NA	No	Not detected in unfiltered or filtered samples.
Arsenic	µg/L	340	150		340	150		2,130	633	5,458	1,060 to 16,500	Yes	Arsenic values apply to dissolved only.
Barium	µg/L	NV	200		NV	NV		NV	NV	NA	NA	No	Not detected in unfiltered or filtered samples.
Beryllium	µg/L	NV	3.6		NV	NV		148	3.8	NA	NA	No	Not detected in unfiltered or filtered samples.
Cadmium	µg/L	1.4 - 3.8	0.18 - 0.37	H	2	0.25	H	1.80	0.75	11.1	0.002 to 32,000	Yes	EPA value based on hardness of 100 mg/L.
Calcium	µg/L	NV	NV		NV	NV		NV	NV	NA	NA	No	
Chromium	µg/L	NV	42	H	570	74		89	NV	NA	NA	No	
Cobalt	µg/L	NV	24		NV	NV		810	<4.4	NA	NA	No	
Copper	µg/L	13.2 - 32.1	8.8 - 19.6	H	BLM	BLM		5.0	0.21	NA	NA	No	
Iron	µg/L	NV	NV		NV	1,000		NV	16	3,832	320 to 45,900	Yes	
Lead	µg/L	38	5.4		65	2.5		22	NV	NA	NA	No	Not detected in unfiltered or filtered samples.
Magnesium	µg/L	NV	NV		NV	NV		NV	NV	NA	NA	No	
Manganese	µg/L	NV	NV		NV	NV		1,270	<1,100	NA	NA	No	
Mercury	µg/L	1.4	0.77		1.4	0.77		0.87	0.87	NA	NA	No	Not detected in unfiltered or filtered samples.
Nickel	µg/L	410 - 912	45.6 - 101	H	470	52	H	62	45	NA	NA	No	EPA value based on hardness of 100 mg/L.
Potassium	µg/L	NV	NV		NV	NV		NV	NV	NA	NA	No	
Selenium	µg/L	50	5		NV	5		40	25	585	10 to 20,700	Yes	Not detected in unfiltered samples.
Silver	µg/L	2.0 - 10.3	NV	H	3.2	NV		0.20	<0.56	NA	NA	No	Not detected in unfiltered or filtered samples. EPA value based on hardness of 100 mg/L.
Sodium	µg/L	NV	NV		NV	NV		NV	NV	NA	NA	No	
Thallium	µg/L	NV	10		NV	NV		81	64	NA	NA	No	
Vanadium	µg/L	NV	12		NV	NV		41	430	NA	NA	No	
Zinc	µg/L	118 - 262	118 - 262	H	120	120		47	NV	1,676	290 to 20,000	Yes	EPA value based on hardness of 100 mg/L.

Notes:

Surface water was not available from any of the background locations.

H: Values are hardness-dependent. Range of calculated values across filtered and unfiltered samples shown. Sample-specific values shown in Appendix Table H-1a and H-1b.

NV: No value

BLM: Copper value based on BLM model.

NA: Not assessed.

[a] Values from NJDEP (2009)

[b] EPA AWQC values from http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm.

Table 4-3. Avian Dietary TRVs used to Assess Potential Ingestion Risks from the COPEC Metals

Parameter	Avian TRV NOAEL	Source
Arsenic	2.24	USEPA 2005a
Cadmium	1.47	USEPA 2005b
Iron	41.7	McGhee et al. (1965), as reported in NAS (1980)
Selenium	0.29	USEPA 2007a
Zinc	66.1	USEPA 2007b

Note:
An avian TRV is not available from the EPA EcoSSL document for iron (USEPA 2003).

Table 4-4. Back-calculated Sediment COPEC Metal Ingestion Benchmarks for Avian Receptors

Receptor	Parameter	Units	Arsenic	Cadmium	Iron	Selenium	Zinc	Comment
Great Blue Heron	TRV-NOAEL	mg/kg-d	2.24	1.47	41.7	0.29	66.1	See Table 4-3 for data sources.
	Body Weight (Kg)	Kg	2.34E+00	2.34E+00	2.34E+00	2.34E+00	2.34E+00	USEPA (1993)
	Sed Ingestion Rate (Kg/d, dw)	Kg/d, dw	8.22E-03	8.22E-03	8.22E-03	8.22E-03	8.22E-03	Calculated from fresh weight food ingestion rate equation from Kushlan (1978), adjusted to dry weight by multiplying by 0.3, and converted to sediment ingestion rate by multiplying by 0.02.
	Home Range	acres	11.1	11.1	11.1	11.1	11.1	USEPA (1993)
	Briar Lake	acres	0.9	0.9	0.9	0.9	0.9	Estimated from aerial
	Area Use Factor	unitless	8.11E-02	8.11E-02	8.11E-02	8.11E-02	8.11E-02	Calculated
	Seasonal Use Factor	unitless	0.83	0.83	0.83	0.83	0.83	Accounts for 2 month period when Briar Lake is likely frozen.
	Back-calculated Sediment Ingestion Benchmark	mg/kg_{dw}	9,421	6,183	175,388	1,220	278,012	Based on a hazard quotient of one.
Mallard Duck	TRV-NOAEL	mg/kg-d	2.24	1.47	41.7	0.29	66.1	See Table 4-3 for data sources.
	Body Weight (Kg)	Kg	1.13E+00	1.13E+00	1.13E+00	1.13E+00	1.13E+00	USEPA (1993)
	Sed Ingestion Rate (Kg/d, dw)	Kg/d, dw	3.60E-04	3.60E-04	3.60E-04	3.60E-04	3.60E-04	Calculated from fresh weight food ingestion rate equation from Nagy (1987), adjusted to dry weight by multiplying by 0.3, and converted to sediment ingestion rate by multiplying by 0.02.
	Home Range	acres	1,432	1,432	1,432	1,432	1,432	USEPA (1993)
	Briar Lake	acres	0.9	0.9	0.9	0.9	0.9	Estimated from aerial
	Area Use Factor	unitless	6.28E-04	6.28E-04	6.28E-04	6.28E-04	6.28E-04	Calculated
	Seasonal Use Factor	unitless	0.67	0.67	0.67	0.67	0.67	Migratory species conservatively assumed present from March through October (8 months of the year).
	Back-calculated Sediment Ingestion Benchmark	mg/kg_{dw}	[a]	[a]	[a]	[a]	[a]	Based on a hazard quotient of one.

Note:

Values based on Brair Lake are also applied to Holly Run evebthough latter represents far lower acreage.

[a] Value exceeds maximum possible concentration (i.e., > 10^6 mg/kg).

Table 4-5. Comparison of Surface Sediment COPEC Metal Results to Benchmarks for the Assessment of Benthic Invertebrates (Measurement Endpoint No. 1-1)

				NJDEP Sediment Criteria				Site Background		USGS NURE Background	
Sample Location	SampleID	COPEC	Result	NJDEP LEL	NJDEP SEL	HQ-NJDEP LEL	HQ-NJDEP SEL	Max Value	HQ-Max Site Bkgd	Max Value	HQ-Max NURE Bkgd
Background	Average of all locations	Arsenic	1.95	9.98	33	0.20	0.06	NE	NE	16	0.12
		Cadmium	1.1	0.6	10	**1.8**	0.11	NE	NE	NR	---
		Iron	5,640	NV	NV	---	---	NE	NE	171,000	0.03
		Selenium	1.5	NV	NV	---	---	NE	NE	4	0.4
		Zinc	151	121	820	**1.3**	0.2	NE	NE	1,103	0.14
Background	SED-BG14-03	Arsenic	3.6 UJ	9.98	33	---	---	NE	NE	16	---
		Cadmium	0.85 J	0.6	10	**1.4**	0.09	NE	NE	NR	---
		Iron	1,850 J	NV	NV	---	---	NE	NE	171,000	0.01
		Selenium	1.5 J	NV	NV	---	---	NE	NE	4	0.4
		Zinc	10.6 UJ	121	820	---	---	NE	NE	1,103	---
Background	SED-BG14-04	Arsenic	1.7 UJ	9.98	33	---	---	NE	NE	16	---
		Cadmium	2	0.6	10	**3.3**	0.2	NE	NE	NR	---
		Iron	1,070 J	NV	NV	---	---	NE	NE	171,000	0.01
		Selenium	5.5 UJ	NV	NV	---	---	NE	NE	4	---
		Zinc	3.9 U	121	820	---	---	NE	NE	1,103	---
Background	SED-BG14-05	Arsenic	3.2 J	9.98	33	0.3	0.1	NE	NE	16	0.2
		Cadmium	0.34 J	0.6	10	0.6	0.03	NE	NE	NR	---
		Iron	14,000 J	NV	NV	---	---	NE	NE	171,000	0.08
		Selenium	3.2 UJ	NV	NV	---	---	NE	NE	4	---
		Zinc	447 J	121	820	**3.7**	0.5	NE	NE	1,103	0.4
Briar Lake	Average of all locations	Arsenic	42.3	9.98	33	**4.2**	**1.3**	3.2	**13**	16	**2.6**
		Cadmium	0.92	0.6	10	**1.5**	0.09	2	0.5	NR	---
		Iron	121,250	NV	NV	---	---	14,000	**8.7**	171,000	0.7
		Selenium	3.6	NV	NV	---	---	1.5	**2.4**	4	0.9
		Zinc	413	121	820	**3.4**	0.5	447	0.9	1,103	0.4
Briar Lake	SED-BL14-01	Arsenic	9 J	9.98	33	0.9	0.3	3.2	**2.8**	16	0.6
		Cadmium	0.37 J	0.6	10	0.6	0.04	2	0.2	NR	---
		Iron	25,500 J	NV	NV	---	---	14,000	**1.8**	171,000	0.1
		Selenium	5 UJ	NV	NV	---	---	1.5	---	4	---
		Zinc	146 J	121	820	**1.2**	0.2	447	0.3	1,103	0.1

Table 4-5. Comparison of Surface Sediment COPEC Metal Results to Benchmarks for the Assessment of Benthic Invertebrates (Measurement Endpoint No. 1-1)

				NJDEP Sediment Criteria				Site Background		USGS NURE Background	
Sample Location	SampleID	COPEC	Result	NJDEP LEL	NJDEP SEL	HQ-NJDEP LEL	HQ-NJDEP SEL	Max Value	HQ-Max Site Bkgd	Max Value	HQ-Max NURE Bkgd
Briar Lake	SW-D14-01 (SW-BL14-01 Dup)	Arsenic	16.9 J	9.98	33	**1.7**	0.5	3.2	**5.3**	16	**1.1**
		Cadmium	0.53 J	0.6	10	0.9	0.1	2	0.3	NR	---
		Iron	50,300 J	NV	NV	---	---	14,000	**3.6**	171,000	0.3
		Selenium	6.6 UJ	NV	NV	---	---	1.5	---	4	---
		Zinc	243 J	121	820	**2.0**	0.3	447	0.5	1,103	0.2
Briar Lake	SED-BL14-02	Arsenic	72.8 J	9.98	33	**7.3**	**2.2**	3.2	**22.8**	16	**4.6**
		Cadmium	1.2 J	0.6	10	**2.0**	0.12	2	0.6	NR	---
		Iron	217,000 J	NV	NV	---	---	14,000	**15.5**	171,000	**1.3**
		Selenium	3.7 J	NV	NV	---	---	1.5	**2.5**	4	0.9
		Zinc	561 J	121	820	**4.6**	0.7	447	**1.3**	1,103	0.5
Briar Lake	SED-BL14-03	Arsenic	65.9 J	9.98	33	**6.6**	**2.0**	3.2	**20.6**	16	**4.1**
		Cadmium	1.4 J	0.6	10	**2.3**	0.1	2	0.7	NR	---
		Iron	187,000 J	NV	NV	---	---	14,000	**13.4**	171,000	**1.1**
		Selenium	4.7 J	NV	NV	---	---	1.5	**3.1**	4	**1.2**
		Zinc	663 J	121	820	**5.5**	0.8	447	1.5	1,103	0.6
Briar Lake	SED-BL14-04	Arsenic	66.8 J	9.98	33	**6.7**	**2.0**	3.2	**20.9**	16	**4.2**
		Cadmium	1.3 J	0.6	10	**2.2**	0.1	2	0.7	NR	---
		Iron	191,000 J	NV	NV	---	---	14,000	**13.6**	171,000	**1.1**
		Selenium	4.3 J	NV	NV	---	---	1.5	**2.9**	4	**1.1**
		Zinc	635 J	121	820	**5.2**	0.8	447	1.4	1,103	0.6
Briar Lake	SED-BL14-05	Arsenic	22.1 J	9.98	33	**2.2**	0.7	3.2	**6.9**	16	**1.4**
		Cadmium	0.69 J	0.6	10	1.2	0.1	2	0.3	NR	---
		Iron	56,700 J	NV	NV	---	---	14,000	**4.1**	171,000	0.3
		Selenium	6.1 UJ	NV	NV	---	---	1.5	---	4	---
		Zinc	227 J	121	820	**1.9**	0.3	447	0.5	1,103	0.2
Holly Run	Average of all locations	Arsenic	1.65	9.98	33	0.2	0.1	3.2	0.5	16	0.1
		Cadmium	0.51	0.6	10	0.9	0.05	2	0.3	NR	---
		Iron	3,545	NV	NV	---	---	14,000	0.3	171,000	0.02
		Selenium	1	NV	NV	---	---	1.5	0.7	4	0.3
		Zinc	6.85	121	820	0.1	0.0	447	0.02	1,103	0.01

Table 4-5. Comparison of Surface Sediment COPEC Metal Results to Benchmarks for the Assessment of Benthic Invertebrates (Measurement Endpoint No. 1-1)

				NJDEP Sediment Criteria				Site Background		USGS NURE Background	
Sample Location	SampleID	COPEC	Result	NJDEP LEL	NJDEP SEL	HQ-NJDEP LEL	HQ-NJDEP SEL	Max Value	HQ-Max Site Bkgd	Max Value	HQ-Max NURE Bkgd
Holly Run	SED-HR14-04	Arsenic	1.7 J	9.98	33	0.2	0.1	3.2	0.5	16	0.1
		Cadmium	0.11 U	0.6	10	---	---	2	---	NR	---
		Iron	4,470	NV	NV	---	---	14,000	0.3	171,000	0.03
		Selenium	3.7 U	NV	NV	---	---	1.5	---	4	---
		Zinc	10.4	121	820	0.09	0.01	447	0.02	1,103	0.01
Holly Run	SED-HR14-05	Arsenic	1.6 J	9.98	33	0.2	0.05	3.2	0.5	16	0.1
		Cadmium	0.97	0.6	10	**1.6**	0.1	2	0.5	NR	---
		Iron	2,620	NV	NV	---	---	14,000	0.2	171,000	0.02
		Selenium	1 J	NV	NV	---	---	1.5	0.7	4	0.3
		Zinc	6.6 U	121	820	---	---	447	---	1,103	---

Notes:

All concentration units are in mg/kg.

U = not detected at value shown; UJ = not detected at estimated value shown, J = estimated value

NV = no value available.

NE = no evaluated (sample was from background location).

A dash (---) indicates that the HQ was not calculated because COPEC was not detected or no benchmark was available.

Comparisons of non-COPEC metal results to benchmarks is shown in Appendix D.

HQ values shown in bold and highlighted are greater than one.

Table 4-6. Summary of AVS/SEM Evaluation Results for Holly Run, Briar Lake, and Background Area Sediments Collected in October 2014 (Measurement Endpoint No. 1-2)

Sample ID	Location	AVS µmoles/g	ΣSEM µmoles/g	SEM/AVS Ratio µmoles/g	$Diff_{SEM-AVS}$ µmoles/g	TOC mg/Kg	$Diff_{SEM-AVS/TOC}$ $\mu moles/g_{OC}$
SED-BG14-03	Background	1.7	1.28	0.752	-0.42	143,000	-2.94
SED-BG14-04	Background	0.93	0.67	0.715	-0.26	24,400	-10.9
SED-BL14-01	Briar Lake	5.9	2.72	0.461	-3.18	18,700	-170
SED-D14-01 (SED-BL14-01 Dup)	Briar Lake	7.2	4.56	0.633	-2.64	44,200	-59.7
SED-BL14-02	Briar Lake	26.4	7.66	0.290	-18.74	101,000	-186
SED-BL14-03	Briar Lake	166	12.5	0.075	-153.48	79,700	-1,926
SED-BL14-04	Briar Lake	14.2	7.47	0.526	-6.73	66,000	-102
SED-BL14-05	Briar Lake	8.8	1.64	0.187	-7.16	38,500	-186
SED-HR14-04	Holly Run	0.64	0.36	0.561	-0.28	5,670	-49.6
SED-HR14-05	Holly Run	7.4	0.33	0.045	-7.07	24,600	-287

Notes:

SEM was calculated by setting non-detect values to zero.

An SEM/AVS Ratio less than one (or a $Diff_{SEM-AVS}$ of less than zero) indicates that potential toxicity due to the SEM metals is not expected.

A $Diff_{SEM-AVS/TOC}$ less than 130 indicates little potential for toxicity. A value between 130 and 3,000 suggests some potential for toxicity from select SEM metals.

Toxicity is not expected when organic carbon normalized excess SEM is less than 150 $\mu mol/g_{oc}$.

Table 4-7. Comparison of Filtered Surface Water COPEC Metal Results to Benchmarks (Measurement Endpoint Nos. 2-2 and 3-1)

Sample Location	SampleID	COPEC	Result	NJDEP Acute	NJDEP Chronic	HQ-NJDEP Acute	HQ-NJDEP Chronic	EPA Chronic AWQC	HQ-EPA AWQC	Suter and Tsao (1996) EC20-Daphnid	Suter and Tsao (1996) HQ-Daphnid
Briar Lake	Average of all samples	Arsenic	2.1	340	150	0.006	0.014	--	--	633	--
		Cadmium	2.7 U	1.82	0.215	--	--	--	--	0.75	--
		Iron	408	NV	NV	--	--	1,000	0.41	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	3.3 U	143	143	--	--	--	--	NV	--
Briar Lake	SW-BL14-01	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	0.3 U	1.82	0.215	--	--	--	--	0.75	--
		Iron	763	NV	NV	--	--	1,000	0.76	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	4.2 U	143	143	--	--	--	--	NV	--
Briar Lake	SW-D14-01 (SW-BL14-01 Dup)	Arsenic	2.1 J	340	150	0.006	0.014	--	--	633	--
		Cadmium	0.42 U	1.69	0.204	--	--	--	--	0.75	--
		Iron	718	NV	NV	--	--	1,000	0.72	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	3.1 U	134	134	--	--	--	--	NV	--
Briar Lake	SW-BL14-02	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	5 U	1.97	0.227	--	--	--	--	0.75	--
		Iron	106	NV	NV	--	--	1,000	0.11	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	2.4 U	152	152	--	--	--	--	NV	--
Briar Lake	SW-BL14-03	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	5 U	1.82	0.215	--	--	--	--	0.75	--
		Iron	86.7 U	NV	NV	--	--	1,000	--	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	2.3 U	143	143	--	--	--	--	NV	--
Holly Run	Average of all samples	Arsenic	2.2	340	150	0.006	0.015	--	--	633	--
		Cadmium	0.34	1.82	0.215	0.2	**1.6**	--	--	0.75	--
		Iron	555	NV	NV	--	--	1,000	0.56	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	14.2	143	143	0.1	0.1	--	--	NV	--
Holly Run	SW-HR14-01	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	0.27 J	2.52	0.272	0.11	0.99	--	--	0.75	0.36
		Iron	299	NV	NV	--	--	1,000	0.30	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	6.4 U	187	187	--	--	--	--	NV	--

Table 4-7. Comparison of Filtered Surface Water COPEC Metal Results to Benchmarks (Measurement Endpoint Nos. 2-2 and 3-1)

Sample Location	SampleID	COPEC	Result	NJDEP Acute	NJDEP Chronic	HQ-NJDEP Acute	HQ-NJDEP Chronic	EPA Chronic AWQC	HQ-EPA AWQC	Suter and Tsao (1996) EC20-Daphnid	Suter and Tsao (1996) HQ-Daphnid
Holly Run	SW-HR14-02	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	0.28 U	1.78	0.211	--	--	--	--	0.75	--
		Iron	744	NV	NV	--	--	1,000	0.74	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	10.5 U	140	140	--	--	--	--	NV	--
Holly Run	SW-HR14-03	Arsenic	2.2 J	340	150	0.006	0.015	--	--	633	--
		Cadmium	0.33 J	1.73	0.206	0.2	**1.6**	--	--	0.75	0.44
		Iron	1,330	NV	NV	--	--	1,000	**1.3**	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	6.1 U	136	136	--	--	--	--	NV	--
Holly Run	SW-HR14-04	Arsenic	2 J	340	150	0.006	0.013	--	--	633	--
		Cadmium	0.34 J	1.77	0.210	0.2	**1.6**	--	--	0.75	0.45
		Iron	629	NV	NV	--	--	1,000	0.63	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	0.57 UJ	139	139	--	--	--	--	NV	--
Holly Run	SW-HR14-05	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	5 U	1.59	0.194	--	--	--	--	0.75	--
		Iron	305	NV	NV	--	--	1,000	0.31	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	5.2 UJ	127	127	--	--	--	--	NV	--
Holly Run	SW-HR14-06	Arsenic	10 U	340	150	--	--	--	--	633	--
		Cadmium	5 U	3.77	0.365	--	--	--	--	0.75	--
		Iron	25 J	NV	NV	--	--	1,000	0.025	16	--
		Selenium	35 U	50	5	--	--	--	--	25	--
		Zinc	70.8	262	262	0.3	0.3	--	--	NV	--

Notes:
All concentration units are in µg/L
Supporting calculations for hardness-dependent NJDEP benchmarks are shown in Appendix C
U = not detected at value shown; UJ = not detected at estimated value shown, J = estimated valu
NV = no value available
A dash (---) indicates that the HQ was not calculated because COPEC was not detected or no benchmark was available
Comparisons of non-COPEC metal results to benchmarks is shown in Appendix D
HQ values shown in bold and highlighted are greater than one

Table 4-8 Comparison of Filtered Surface Water COPEC Metal Results to Benchmarks Related to Growth, Survival and Reproduction in Fish (Measurement Endpoint No. 3-2)

				Suter and Tsao (1996)		ECOTox Database	
Sample Location	SampleID	COPEC	Result	EC20-Fish	HQ-Trout	No Effect Values (Geomean)	HQ-EcoTox
Briar Lake	Average of all locations	Arsenic	2.1	2,130	0.0010	5,458	0.0004
		Cadmium	2.7 U	1.8	--	11.1	---
		Iron	408	NV	--	3,832	0.11
		Selenium	35 U	40	--	585	---
		Zinc	3.3 U	47	--	1,676	---
Briar Lake	SW-BL14-01	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	0.3 U	1.8	--	11.1	---
		Iron	763	NV	--	3,832	0.20
		Selenium	35 U	40	--	585	---
		Zinc	4.2 U	47	--	1,676	---
Briar Lake	SW-D14-01 (SW-BL14-01 Dup)	Arsenic	2.1 J	2,130	0.0010	5,458	0.0004
		Cadmium	0.42 U	1.8	--	11.1	---
		Iron	718	NV	--	3,832	0.19
		Selenium	35 U	40	--	585	---
		Zinc	3.1 U	47	--	1,676	---
Briar Lake	SW-BL14-02	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	5 U	1.8	--	11.1	---
		Iron	106	NV	--	3,832	0.03
		Selenium	35 U	40	--	585	---
		Zinc	2.4 U	47	--	1,676	---
Briar Lake	SW-BL14-03	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	5 U	1.8	--	11.1	---
		Iron	86.7 U	NV	--	3,832	---
		Selenium	35 U	40	--	585	---
		Zinc	2.3 U	47	--	1,676	---
Holly Run	Average of all locations	Arsenic	2.2	2,130	0.001	5,458	0.0004
		Cadmium	0.34	1.8	0.19	11.1	0.031
		Iron	555	NV	--	3,832	0.14
		Selenium	35 U	40	--	585	---
		Zinc	14.2	47	0.30	1,676	0.008
Holly Run	SW-HR14-01	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	0.27 J	1.8	0.15	11.1	0.02
		Iron	299	NV	--	3,832	0.08
		Selenium	35 U	40	--	585	---
		Zinc	6.4 U	47	--	1,676	---

Table 4-8 Comparison of Filtered Surface Water COPEC Metal Results to Benchmarks Related to Growth, Survival and Reproduction in Fish (Measurement Endpoint No. 3-2)

				Suter and Tsao (1996)		ECOTox Database	
Sample Location	SampleID	COPEC	Result	EC20-Fish	HQ-Trout	No Effect Values (Geomean)	HQ-EcoTox
Holly Run	SW-HR14-02	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	0.28 U	1.8	--	11.1	---
		Iron	744	NV	--	3,832	0.19
		Selenium	35 U	40	--	585	---
		Zinc	10.5 U	47	--	1,676	---
Holly Run	SW-HR14-03	Arsenic	2.2 J	2,130	0.0010	5,458	0.0004
		Cadmium	0.33 J	1.8	0.18	11.1	0.03
		Iron	1,330	NV	--	3,832	0.35
		Selenium	35 U	40	--	585	---
		Zinc	6.1 U	47	--	1,676	---
Holly Run	SW-HR14-04	Arsenic	2 J	2,130	0.0009	5,458	0.0004
		Cadmium	0.34 J	1.8	0.19	11.1	0.03
		Iron	629	NV	--	3,832	0.16
		Selenium	35 U	40	--	585	---
		Zinc	0.57 UJ	47	--	1,676	---
Holly Run	SW-HR14-05	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	5 U	1.8	--	11.1	---
		Iron	305	NV	--	3,832	0.08
		Selenium	35 U	40	--	585	---
		Zinc	5.2 UJ	47	--	1,676	---
Holly Run	SW-HR14-06	Arsenic	10 U	2,130	--	5,458	---
		Cadmium	5 U	1.8	--	11.1	---
		Iron	25 J	NV	--	3,832	0.01
		Selenium	35 U	40	--	585	---
		Zinc	70.8	47	**1.5**	1,676	0.042

Notes:
All concentration units are in µg/L.
U = not detected at value shown; UJ = not detected at estimated value shown, J = estimated valu
NV = no value available.
A dash (---) indicates that the HQ was not calculated because COPEC was not detected or no benchmark was availabl
HQ values shown in bold and highlighted are greater than one

Table 4-9. Comparison of Observed Sediment Concentrations to Sediment Ingestion Benchmarks for the Mallard Duck (Measurement Endpont No. 4-1)

Sample Location	SampleID	COPEC	Result	Sediment Ingestion Benchmark	HQ-Duck
Briar Lake	Average of All Samples	Arsenic	42	1.0E+06	4.2E-05
		Cadmium	0.9	1.0E+06	9.0E-07
		Iron	121,250	1.0E+06	1.2E-01
		Selenium	3.6	1.0E+06	3.6E-06
		Zinc	413	1.0E+06	4.1E-04
Briar Lake	SED-BL14-01	Arsenic	9 J	1.0E+06	9.0E-06
		Cadmium	0.37 J	1.0E+06	3.7E-07
		Iron	25,500 J	1.0E+06	2.6E-02
		Selenium	5 UJ	1.0E+06	---
		Zinc	146 J	1.0E+06	1.5E-04
Briar Lake	SW-D14-01 (SW-BL14-01 Dup)	Arsenic	16.9 J	1.0E+06	1.7E-05
		Cadmium	0.53 J	1.0E+06	5.3E-07
		Iron	50,300 J	1.0E+06	5.0E-02
		Selenium	6.6 UJ	1.0E+06	---
		Zinc	243 J	1.0E+06	2.4E-04
Briar Lake	SED-BL14-02	Arsenic	72.8 J	1.0E+06	7.3E-05
		Cadmium	1.2 J	1.0E+06	1.2E-06
		Iron	217,000 J	1.0E+06	2.2E-01
		Selenium	3.7 J	1.0E+06	3.7E-06
		Zinc	561 J	1.0E+06	5.6E-04
Briar Lake	SED-BL14-03	Arsenic	65.9 J	1.0E+06	6.6E-05
		Cadmium	1.4 J	1.0E+06	1.4E-06
		Iron	187,000 J	1.0E+06	1.9E-01
		Selenium	4.7 J	1.0E+06	4.7E-06
		Zinc	663 J	1.0E+06	6.6E-04

Table 4-9. Comparison of Observed Sediment Concentrations to Sediment Ingestion Benchmarks for the Mallard Duck (Measurement Endpont No. 4-1)

Sample Location	SampleID	COPEC	Result	Sediment Ingestion Benchmark	HQ-Duck
Briar Lake	SED-BL14-04	Arsenic	66.8 J	1.0E+06	6.7E-05
		Cadmium	1.3 J	1.0E+06	1.3E-06
		Iron	191,000 J	1.0E+06	1.9E-01
		Selenium	4.3 J	1.0E+06	4.3E-06
		Zinc	635 J	1.0E+06	6.4E-04
Briar Lake	SED-BL14-05	Arsenic	22.1 J	1.0E+06	2.2E-05
		Cadmium	0.69 J	1.0E+06	6.9E-07
		Iron	56,700 J	1.0E+06	5.7E-02
		Selenium	6.1 UJ	1.0E+06	---
		Zinc	227 J	1.0E+06	2.3E-04

Notes:

All concentration units are in mg/kg

Data qualifers: U = not detected at value shown; UJ = not detected at estimated value shown, J = estimated value

A dash (---) indicates that the HQ was not calculated because COPEC was not detecte

HQ values shown in bold and highlighted are greater than on

Table 4-10. Comparison of Observed Sediment Concentrations to Sediment Ingestion Benchmarks for the Great Blue Heron (Measurement Endpoint No. 5-1)

Sample Location	SampleID	COPEC	Result	Sediment Ingestion Benchmark	HQ-Heron
Briar Lake	Average of All Locations	Arsenic	42	9,421	4.5E-03
		Cadmium	0.92	6,183	1.5E-04
		Iron	121,250	175,388	6.9E-01
		Selenium	3.6	1,220	2.9E-03
		Zinc	413	278,012	1.5E-03
Briar Lake	SED-BL14-01	Arsenic	9 J	9,421	9.6E-04
		Cadmium	0.37 J	6,183	6.0E-05
		Iron	25,500 J	175,388	
		Selenium	5 UJ	1,220	---
		Zinc	146 J	278,012	5.3E-04
Briar Lake	SW-D14-01 (SW-BL14-01 Dup)	Arsenic	16.9 J	9,421	1.8E-03
		Cadmium	0.53 J	6,183	8.6E-05
		Iron	50,300 J	175,388	2.9E-01
		Selenium	6.6 UJ	1,220	---
		Zinc	243 J	278,012	8.7E-04
Briar Lake	SED-BL14-02	Arsenic	72.8 J	9,421	7.7E-03
		Cadmium	1.2 J	6,183	1.9E-04
		Iron	217,000 J	175,388	**1.2E+00**
		Selenium	3.7 J	1,220	3.0E-03
		Zinc	561 J	278,012	2.0E-03
Briar Lake	SED-BL14-03	Arsenic	65.9 J	9,421	7.0E-03
		Cadmium	1.4 J	6,183	2.3E-04
		Iron	187,000 J	175,388	**1.1E+00**
		Selenium	4.7 J	1,220	3.9E-03
		Zinc	663 J	278,012	2.4E-03
Briar Lake	SED-BL14-04	Arsenic	66.8 J	9,421	7.1E-03
		Cadmium	1.3 J	6,183	2.1E-04
		Iron	191,000 J	175,388	**1.1E+00**
		Selenium	4.3 J	1,220	3.5E-03
		Zinc	635 J	278,012	2.3E-03

Table 4-10. Comparison of Observed Sediment Concentrations to Sediment Ingestion Benchmarks for the Great Blue Heron (Measurement Endpoint No. 5-1)

Sample Location	SampleID	COPEC	Result	Sediment Ingestion Benchmark	HQ-Heron
Briar Lake	SED-BL14-05	Arsenic	22.1 J	9,421	2.3E-03
		Cadmium	0.69 J	6,183	1.1E-04
		Iron	56,700 J	175,388	3.2E-01
		Selenium	6.1 UJ	1,220	---
		Zinc	227 J	278,012	8.2E-04
Holly Run	Average of All Locations	Arsenic	1.65	9,421	1.8E-04
		Cadmium	0.51	6,183	8.3E-05
		Iron	3,545	175,388	2.0E-02
		Selenium	1	1,220	8.2E-04
		Zinc	6.85	278,012	2.5E-05
Holly Run	SED-HR14-04	Arsenic	1.7 J	9,421	1.8E-04
		Cadmium	0.11 U	6,183	---
		Iron	4,470	175,388	2.5E-02
		Selenium	3.7 U	1,220	---
		Zinc	10.4	278,012	3.7E-05
Holly Run	SED-HR14-05	Arsenic	1.6 J	9,421	1.7E-04
		Cadmium	0.97	6,183	1.6E-04
		Iron	2,620	175,388	1.5E-02
		Selenium	1 J	1,220	8.2E-04
		Zinc	6.6 U	278,012	---

Notes:

All concentration units are in mg/kg

Data qualifers: U = not detected at value shown; UJ = not detected at estimated value shown, J = estimated value

A dash (---) indicates that the HQ was not calculated because COPEC was not detecte

HQ values shown in bold and highlighted are greater than on

Table 4-11. Calculation of Site-Specific Sedment Screening Values for Chlorobenzene

Evaluation	Location	Sample	log K_{ow}[a]	K_{oc}[b]	Freshwater Chronic Value (µg/L)[c]	TOC %	Freshwater Sediment Screening Value (mg/kg)	Freshwater Sediment Screening Value (µg/kg)	HydroQual 2006 Sediment (µg/kg)	Observed < Screen
A. Comparison Based on Average TOC Results (Across All Samples)	Holly Run	HR-04	2.86	648	47	5.61	1.709	1,709	9.2	Yes
	Briar Lake	BL-01	2.86	648	47	5.61	1.709	1,709	0.9	Yes
	Briar Lake	BL-02	2.86	648	47	5.61	1.709	1,709	33	Yes
	Briar Lake	BL-02 Dup	2.86	648	47	5.61	1.709	1,709	35	Yes
	Briar Lake	BL-03	2.86	648	47	5.61	1.709	1,709	61	Yes
	Background	BG-01	2.86	648	47	5.61	1.709	1,709	ND (6.5 U)	---
	Background	BG-02	2.86	648	47	5.61	1.709	1,709	ND (30 U)	---
	Background	BG-03	2.86	648	47	5.61	1.709	1,709	ND (51 U)	---
	Background	BG-04	2.86	648	47	5.61	1.709	1,709	ND (12 U)	---
B. Comparison Based on Paired Sample and TOC Results	Holly Run	HR-04	2.86	648	47	2.70	0.822	822	9.2	Yes
	Briar Lake	BL-01	2.86	648	47	0.74	0.225	225	0.9	Yes
	Briar Lake	BL-02	2.86	648	47	3.04	0.926	926	33	Yes
	Briar Lake	BL-02 Dup	2.86	648	47	1.78	0.542	542	35	Yes
	Briar Lake	BL-03	2.86	648	47	2.54	0.774	774	61	Yes
	Background	BG-01	2.86	648	47	1.56	0.475	475	ND (6.5 U)	---
	Background	BG-02	2.86	648	47	10.40	3.168	3,168	ND (30 U)	---
	Background	BG-03	2.86	648	47	24.70	7.524	7,524	ND (51 U)	---
	Background	BG-04	2.86	648	47	3.07	0.935	935	ND (12 U)	---

Notes:

Calculation is that same as used by EPA Region 3 (http://www.epa.gov/reg3hwmd/risk/eco/btag/sbv/fwsed/FW_Sed_TOC_Table_7-06.xls) but uses updated freshwater criterion from NJDEP (2009).

[a] K_{ow} value from EPA Region III workbook. Current Risk Assessment Information System value from ORNL is very similar (Log K_{ow} = 2.84).

[b] Equation from U.S. EPA. 1996. Eco Update: Ecotox Thresholds. Office of Solid Waste and Emergency Response. Washington, D.C. EPA 540/F95/038.

[c] Freshwater screening value from NJDEP (2007).

Table 4-12. Summary of Chemicals with Elevated Detection Limits from EPA SLERA

Parameter	SampleID	Sample Location	Value	LabFlag	EPA SLERA[a] Screen Value	EPA SLERA[a] Screen Value Source
Carbon disulfide	BG-01	Background	8.4	U	0.851	R3 FW sediment
Carbon disulfide	BG-03	Background	56	U	0.851	R3 FW sediment
Carbon disulfide	BL-01	Briar Lake	8.7	U	0.851	R3 FW sediment
Carbon disulfide	BL-02	Briar Lake	12	U	0.851	R3 FW sediment
Carbon disulfide	BL-03	Briar Lake	17	U	0.851	R3 FW sediment
Carbon disulfide	HR-04	Holly Run	10	U	0.851	R3 FW sediment
2,4-Dinitrophenol	BG-01	Background	2,800	U	6.21	R5 FW ESLs
2,4-Dinitrophenol	BG-03	Background	12,000	U	6.21	R5 FW ESLs
2,4-Dinitrophenol	BL-01	Briar Lake	1,100	U	6.21	R5 FW ESLs
2,4-Dinitrophenol	BL-02	Briar Lake	1,200	U	6.21	R5 FW ESLs
2,4-Dinitrophenol	BL-03	Briar Lake	1,300	U	6.21	R5 FW ESLs
2,4-Dinitrophenol	HR-04	Holly Run	1,000	U	6.21	R5 FW ESLs
2-Methylphenol	BG-01	Background	700	U	12	ORNL EqP
2-Methylphenol	BG-03	Background	3,100	U	12	ORNL EqP
2-Methylphenol	BL-01	Briar Lake	260	U	12	ORNL EqP
2-Methylphenol	BL-02	Briar Lake	300	U	12	ORNL EqP
2-Methylphenol	BL-03	Briar Lake	320	U	12	ORNL EqP
2-Methylphenol	HR-04	Holly Run	260	U	12	ORNL EqP
4-Nitrophenol	BG-01	Background	2,800	U	13.3	R5 FW ESLs
4-Nitrophenol	BG-03	Background	12,000	U	13.3	R5 FW ESLs
4-Nitrophenol	BL-01	Briar Lake	1,100	U	13.3	R5 FW ESLs
4-Nitrophenol	BL-02	Briar Lake	1,200	U	13.3	R5 FW ESLs
4-Nitrophenol	BL-03	Briar Lake	1,300	U	13.3	R5 FW ESLs
4-Nitrophenol	HR-04	Holly Run	1,000	U	13.3	R5 FW ESLs
Hexachlorocyclopentadiene	BG-01	Background	2,800	U	44	R2(NY) FW sed
Hexachlorocyclopentadiene	BG-03	Background	12,000	U	44	R2(NY) FW sed
Hexachlorocyclopentadiene	BL-01	Briar Lake	1,100	U	44	R2(NY) FW sed
Hexachlorocyclopentadiene	BL-02	Briar Lake	1,200	U	44	R2(NY) FW sed
Hexachlorocyclopentadiene	BL-03	Briar Lake	1,300	U	44	R2(NY) FW sed
Hexachlorocyclopentadiene	HR-04	Holly Run	1,000	U	44	R2(NY) FW sed

Table 4-12. Summary of Chemicals with Elevated Detection Limits from EPA SLERA

Parameter	SampleID	Sample Location	Value	LabFlag	EPA SLERA[a] Screen Value	EPA SLERA[a] Screen Value Source
Total Organic Carbon	BG-01	Background	1.55		---	---
Total Organic Carbon	BG-03	Background	33.7		---	---
Total Organic Carbon	BL-01	Briar Lake	0.93		---	---
Total Organic Carbon	BL-02	Briar Lake	2.75		---	---
Total Organic Carbon	BL-03	Briar Lake	1.86		---	---
Total Organic Carbon	HR-04	Holly Run	2.34		---	---
Percent Moisture	BG-01	Background	27.7		---	---
Percent Moisture	BG-02	Background	76.4			
Percent Moisture	BG-03	Background	85.8		---	---
Percent Moisture	BG-04	Background	51.6			
Percent Moisture	BL-01	Briar Lake	25.5		---	---
Percent Moisture	BL-02	Briar Lake	43.9		---	---
Percent Moisture	BL-02 Dup	Briar Lake	40.3			
Percent Moisture	BL-03	Briar Lake	48.8		---	---
Percent Moisture	HR-04	Holly Run	45.1		---	---

Notes:

All concentration units are µg/kg (dry weight), except for TOC (% dry weight).

Values shown as reported in 2010 SLERA that was provided as part of EPA correspondence dated 6/20/2013 to dmi.

Lab flags: U = not detected at value shown.

SLERA screen value souce descriptions:

R3 FW sediment = EPA Region 3 freshwater sediment criterion

ORNL EqP = ORNL equilibrium partitioning based on 1% TOC

R5 FW ESLs = EPA Region 5 Ecological Screening Level (EPA 2003)

R2(NY) FW sed = NYSDEC (1999) screening value based on 1% TOC

[a]EPA SLERA was prepared in 2010. Screening values are from SERAS software version that was available at that time.